SY3662

±60A@±20V Digital Bipolar Power Supply System

CAENels
Gear for Science

User's Manual

MAGNET POWER SUPPLY SYSTEMS

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Rev. 1.3 – February 2015

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Document Revision	Date	Comment
0.1	September 17th 2012	Draft release
1.0	November 22nd 2012	First release
1.1	December 6th 2012	Minor updates
1.2	October 30th 2014	Manual graphics changed
1.3	February 13th 2015	Ripple specification referred to a resistive load

Safety information - Warnings

CAEN ELS will repair or replace any product within the guarantee period if the Guarantor declares that the product is defective due to workmanship or materials and has not been caused by mishandling, negligence on behalf of the User, accident or any abnormal conditions or operations.

Please read carefully the manual before operating any part of the instrument

WARNING

High voltage inside, do NOT open the boxes

CAEN ELS d.o.o. declines all responsibility for damages or injuries caused by an improper use of the Modules due to negligence on behalf of the User. It is strongly recommended to read thoroughly this User's Manual before any kind of operation.

CAEN ELS d.o.o. reserves the right to change partially or entirely the contents of this Manual at any time and without giving any notice.

Disposal of the Product

The product must never be dumped in the Municipal Waste. Please check your local regulations for disposal of electronics products.

Read over the instruction manual carefully before using the instrument.
The following precautions should be strictly observed before using the SY3662:

WARNING

- Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in this manual.
- Do not use the device if it is damaged. Before you use the device, inspect the instrument for possible cracks or breaks before each use.
- Do not operate the device around explosives gas, vapor or dust.
- Always use the device with the cables provided.
- Turn off the device before establishing any connection.
- Do not operate the device with the cover removed or loosened.
- Do not install substitute parts or perform any unauthorized modification to the product.
- Return the product to the manufacturer for service and repair to ensure that safety features are maintained

CAUTION

- This instrument is designed for indoor use and in area with low condensation.

The following table shows the general environmental requirements for a correct operation of the instrument:

Environmental Conditions	Requirements
Operating Temperature	5°C to 40°C
Operating Humidity	30% to 85% RH (non-condensing)
Storage Temperature	-10°C to 60°C
Storage Humidity	5% to 90% RH (non-condensing)

1. Introduction

This chapter describes the general characteristics and main features of the SY3662 dual bipolar power supply system.

1.1 SY3662 Overview

High efficiency, extreme stability, easiness of configuration and maintenance are the key features of the SY3662 bipolar power supply (PS) system.

The SY3662 houses up to 2 independent current-controlled digital bipolar power supply modules – i.e. A3660BS - rated at ±60A @ ±20V.

A complete two-channel system fits in a single 19-inch 3U standard crate, including the two separate and independent bulk power supplies – i.e. A3667 – that include also the auxiliary power supply.

Each module implements a completely digital control loop with a propriety Pulse Width Modulation (PWM) generation technique, already implemented on the modules of the SY3664 system and in the SY2604 ones.
This feature makes the system extremely versatile and easy to "tune" to any load condition.

The A3660BS modules, as in the other A36xxBS ones of the SY3634, are internally composed by a Control Board (CB) and a Power Board (PB) that are mechanically connected: communication between boards is performed mainly by digital signals in order to avoid possible analog signal corruption and undesired noise pick-up.

The control board houses a dedicated digital signal processor (DSP) that performs the actuation of the signals on the output stage drivers and a FPGA that performs the current control loop and supervises all process as communication, diagnostics and interlock handling. This is the main improvement, together with enhanced current stability, of the A3660BS modules respect to the "lower current" predecessors (A36605BS, A3610BS, A3620BS and A3630BS).

Remote communication is guaranteed by means of a standard RJ-45 Ethernet 10/100 auto-sensing socket accessible from each module front panel; the power supply can also be locally monitored and controlled via an encoder and a graphic color display featuring user-friendly menus.

1.2 System Parts

An entire operational SY3662 system (**Figure 1**) is composed by a single 19-inch crate and it has three main different composing parts:

- the 19" – 3U SY3662 system crate;
- the A3660BS bipolar power supply modules (up to 2 modules per crate);
- the A3667 bulk and auxiliary power supplies (up to two per crate);

Figure 1: front view of a complete SY3662 system

All the elements installed in the crate are independent, which means that any of them can be replaced without the need of changing the other ones.

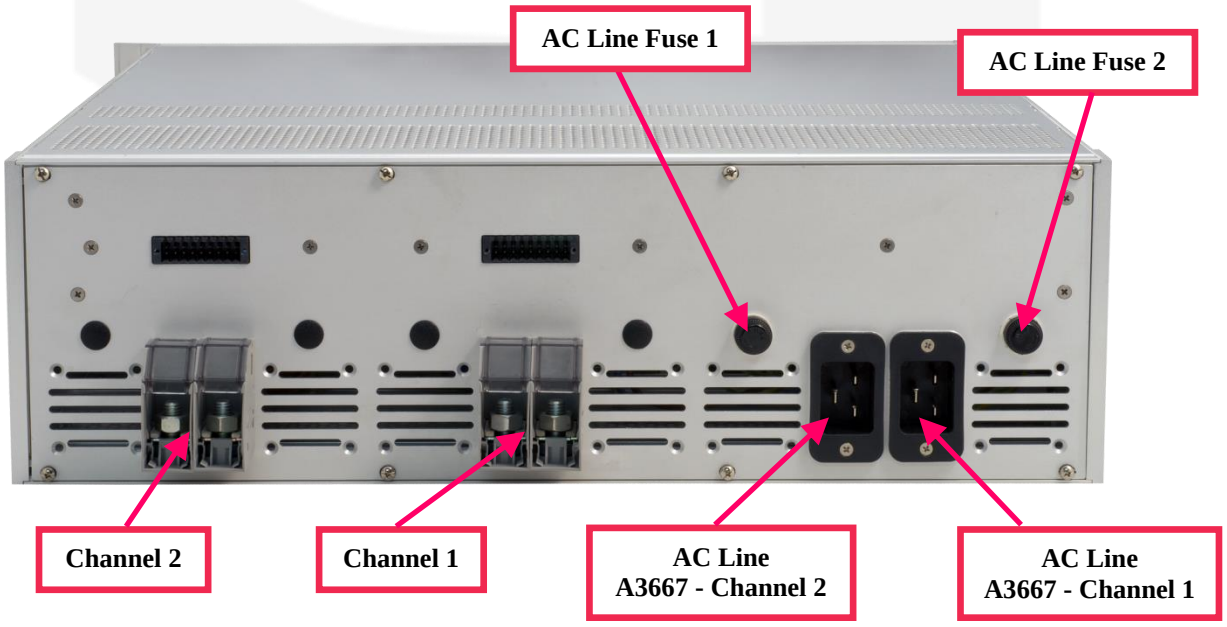
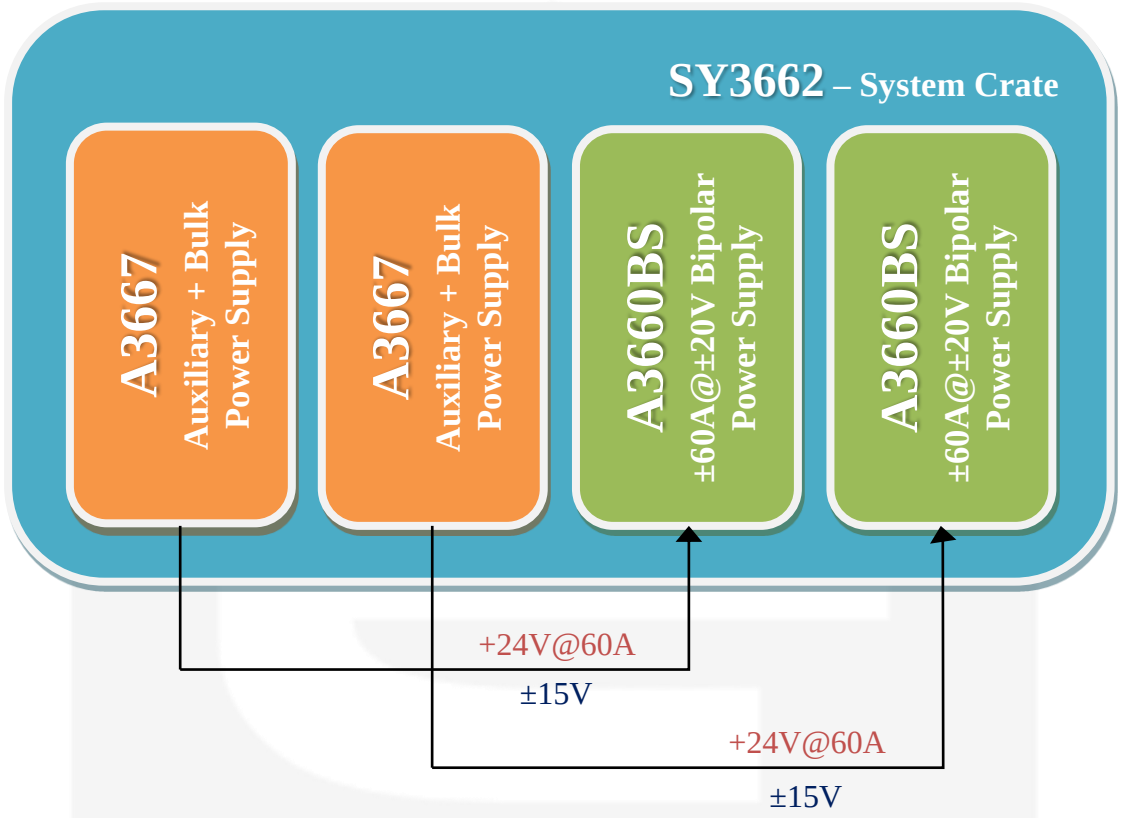


Figure 2: rear view of the SY3662 system

AC Line Fuse 1 is obviously connected to the A3667 power unit dedicated to channel 1 and AC Line Fuse 2 to the one that feeds channel 2, so that it is possible for a channel to continue working while the other one has experienced a particular fault condition that made the fuse blow.

Channel interlock connectors, current output connectors and AC line input plugs are all available on the SY3662 rear panel, as shown in

Figure 2.



The SY3662 system is composed by two A3667 bulk and power supply units and by two A3660BS digital bipolar power supply modules.

As indicated in the diagram, each A3667 delivers the auxiliary outputs (+15V and -15V) and the DC-Link (+24V) – i.e. bulk voltage – to the corresponding A3660BS module. The A3660BS module connected to a specific A3667 bulk and auxiliary unit also feeds the control signals to monitor and enable/disable the power output of the A3667.

2. Safety and Installation

Please read carefully this general safety and installation information before using the product.

2.1 General Safety Information

This section contains the fundamental safety rules for the installation and operation of the system. Read thoroughly this section before starting any procedure of installation or operation of the product.

Safety Terms and Symbols on the Product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking;
- WARNING indicates an injury hazard not immediately accessible as you read the marking;
- CAUTION indicates a hazard to property including the product.

2.2 Initial Inspection

Prior to shipment this system was inspected and found free of mechanical or electrical defects. Upon unpacking of the system, inspect for any damage, which may have occurred in transit. The inspection should confirm that there is no exterior damage to the system such as broken knobs or connectors and that the front panels are not scratched or cracked.

Keep all packing material until the inspection has been completed. If damage is detected, file a claim with carrier immediately and notify CAEN ELS d.o.o. service personnel.

2.3 Injury Precautions

This section contains the fundamental safety rules for the installation and operation of the system in order to avoid injuries.

2.3.1 Caution

The following safety precautions must be observed during all phases of operation, service and repair of this equipment. Failure to comply with the safety precautions or warnings in this document violates safety standards of design, manufacture and intended use of this equipment and may impair the built-in protections within.

CAEN ELS d.o.o. shall not be liable for user's failure to comply with these requirements.

To avoid electrical shock or fire hazard, do not apply a voltage to a load that is outside the range specified for that load.

Do Not Operate Without Covers.

To avoid electric shock or fire hazard, do not operate this product with covers or panels removed.

Do Not Operate in Wet/Damp Conditions.

To avoid electrical shock, do not operate this product in wet or damp conditions.

Do Not Operate in an Explosive Atmosphere.

To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.

Do Not Operate With Suspected Failures.

If you suspect there is damage to this product, have it inspected by qualified service personnel.

2.4 Grounding

To minimize shock hazard, the SY3662 power supply system must be connected to an electrical ground. The ground terminal is present on the mains sockets on the back side of the crate.

2.5 Input Ratings

Do not use AC supply which exceeds the input voltage and frequency rating of this instrument. For input voltage and frequency rating of the module see Chapter 6.

For safety reasons, the mains supply voltage fluctuations should not exceed above voltage range.

2.6 Output Connectors

Do not plug or unplug output connectors when power converters are on and the power units are regulating current on the electrical load.

2.7 Live Circuits

Operating personnel must not remove the 19" crates covers. No internal adjustment or component replacement is allowed to non-CAEN ELS d.o.o. personnel. Never replace components with power cables connected.

In order to avoid injuries, always disconnect power plugs, discharge circuits and remove external voltage source before touching components (wait 5 minutes at least).

2.8 Part Replacement and Modifications

Always disconnect power plugs, discharge circuits and remove external voltage source prior to fuse replacement (wait 5 minutes at least).

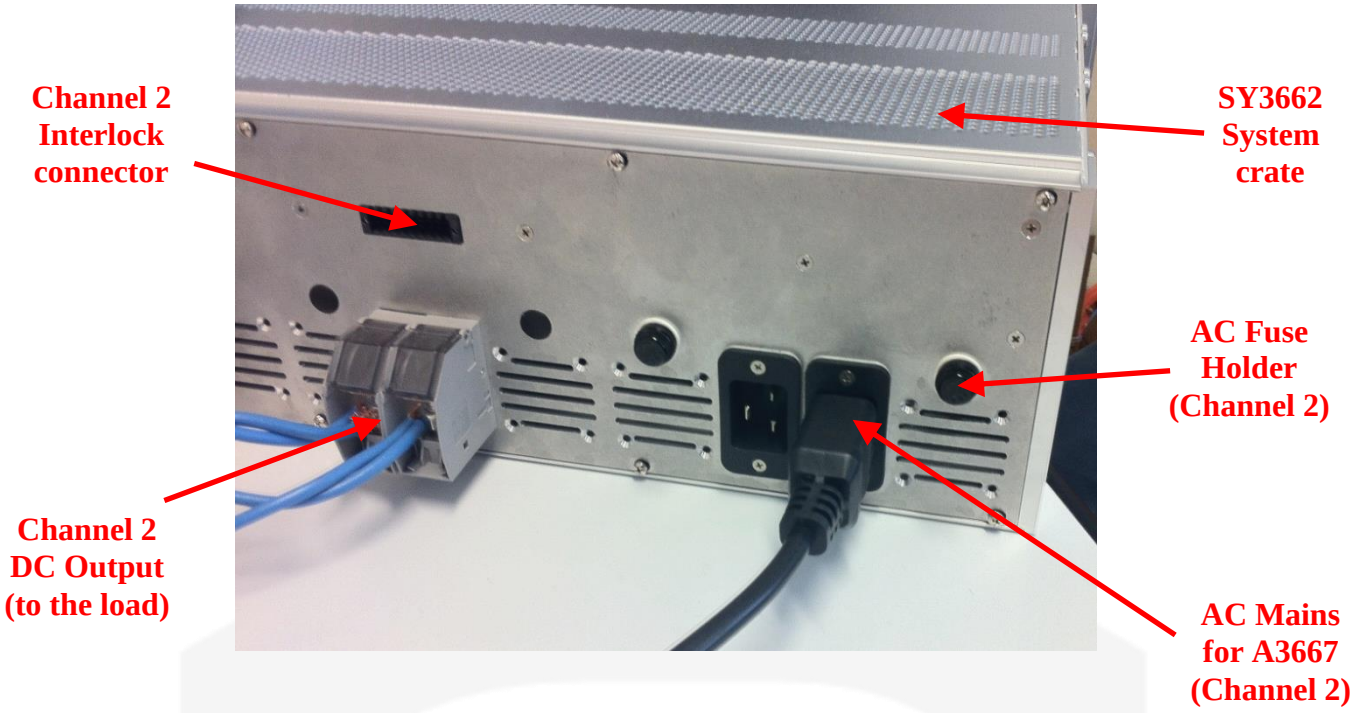
Other parts substitutions and modifications are allowed by authorized CAEN ELS d.o.o. service personnel only.

2.9 Installation Instructions

Follow these instructions in order to correctly install the SY3662 power supply system.

Please execute all these operations with the AC power main plugs disconnected.

Install the A3660BS modules (if not already installed) and the A3667 bulk power supplies (if not already installed) in the 19"- 3U SY3662 system crate.



Connect the necessary AC power plugs in order to power up the corresponding A3667 auxiliary and bulk unit.

AC mains power plugs are standard **IEC connectors type C19**.

Please note that the position of the AC power plugs on the rear side of the bulk crate is "geographic" – i.e. the first socket on the right, looking to the rear of the crate, corresponds to first module on the right, while the one on the left to the module on the left). AC input fuses (5 × 20 mm) are also geographic and input ratings are:

- **8AT** for 220V(AC) mains input;
- **15AT** for 110V(AC) mains input.

The A3667 auxiliary and bulk power supply units are independent one from the other and they are singularly dedicated to supply one A3660BS bipolar power supply module.

Connect the interlock connectors in every relevant socket (wire towards your loads). The interlock connectors are respectively referred to every single channel and can be connected to the desired interlock sources directly involved in that particular channel operation. For further interlock information and pin-out, please refer to section **3.2.2**.

The DC output *Phoenix RWO 8/S* connectors (see **Annex A - Output Connectors** for further information on how to connect them) are to be directly connected to the load – e.g. magnet.

3. SY3662 Description

A description of the SY3662 and the A3660BS modules is herein presented with some in-depth explanations on the basic power supply functionalities.

3.1 A3667 Bulk and Auxiliary Power Supply

The SY3662 digital bipolar power supply system contains up to two units – i.e. A3667 – that should be installed in the two left slots of the system crate and they are used both to power the control electronics and the cooling fans of the A3660BS modules installed in the same crate.

Each A3660BS module is directly connected to its respective A3667 unit and it is independent from the other. This unit is shown in **Figure 3**:

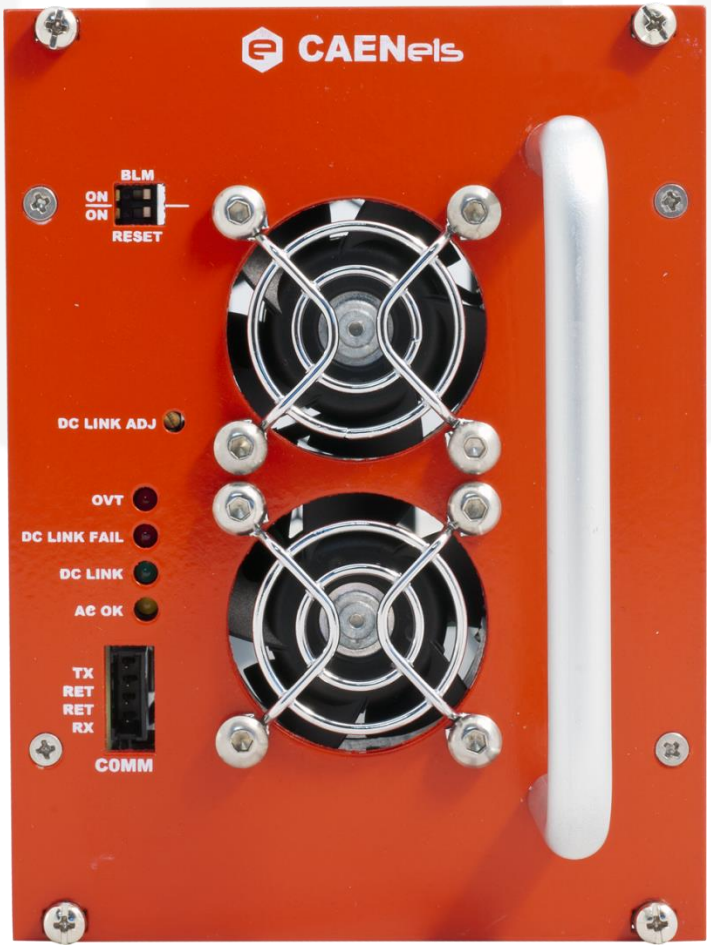


Figure 3: A3667 bulk and auxiliary power supply

The A3667 module is composed of two different stages and independent power supply (internal to the module itself):

- auxiliary power supply, dual output rated at +15V@9W and -15V@9W.
- bulk power supply, rated at 24V@1200W.

3.2 A3660BS Module

The A3660BS bipolar power supply module is the DC-DC stage of the system and regulates output current by performing a digital control loop.

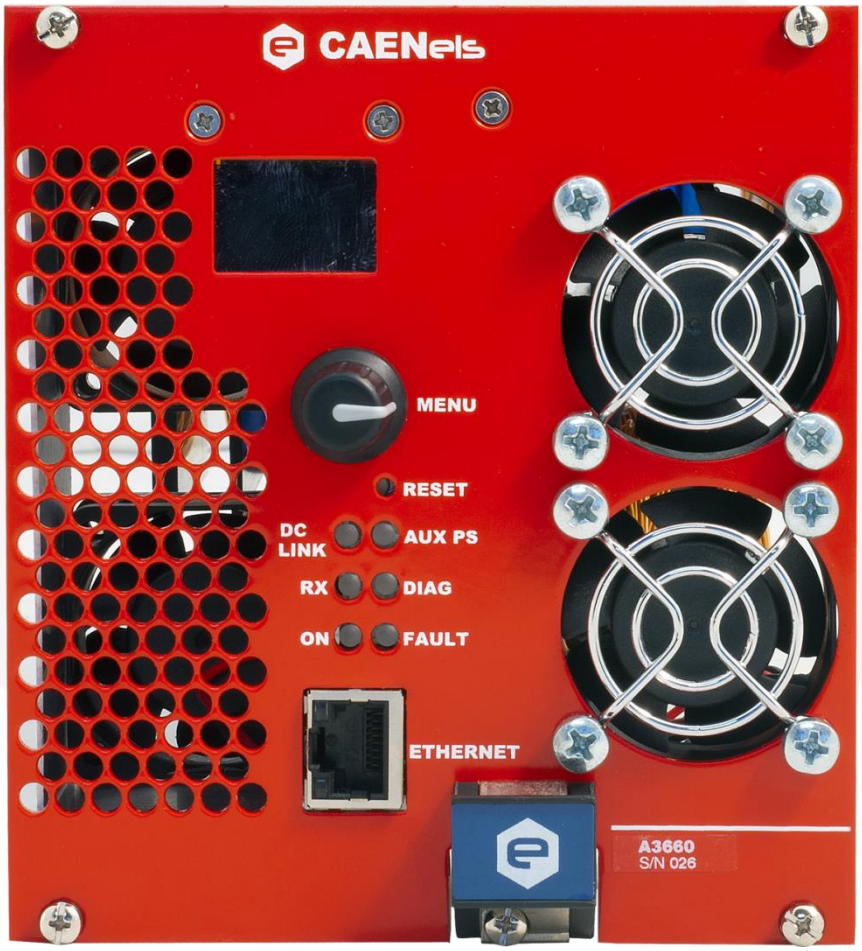


Figure 4: A3660BS module front view

All these modules are bipolar current-controlled power supplies and are especially developed to work in conjunction with a 24V (standard) A3667 bulk power supply unit.

Each A3660BS module front panel has four holes for the air inlet, necessary for the front-to-rear fan cooling system, a standard RJ-45 Ethernet socket, a local

color display, a rotary encoder with push-button capability, a small hole for accessing the local unit reset and six LEDs.

The LEDs are indicators of the power supply status and have to be interpreted as follows:

- **DC LINK** LED: the green light indicates that the respective A3667 bulk power supply voltage is correctly fed to the A3660BS module;
- **AUX PS** LED: the green light indicates that the control electronic section voltage – i.e. 3.3V, directly obtained from the +15V of the A3667 auxiliary power supply section – is correctly into operation;
- **RX** LED: the blue light toggles at every "termination character" reception – i.e. *carriage return* '\r' – and it can also be interpreted as a communication heartbeat indicator;
- **DIAG** LED: the white light it is modulated by an internal PWM counter that is internally serviced and reset by the control electronics at every diagnostic routine execution. If this LED is not modulating its light, the internal diagnostics it is not correctly executed by the module.
- **ON** LED: the blue light indicates that the A3660BS module is in ON state and it is correctly regulating output current;
- **FAULT** LED: the red light indicates that the A3660BS has experienced a generic fault that can be either an internal protection trip or an external interlock intervention. This light does not turn off after a fault until a local or a remote module reset has been performed.

It is important to notice that the blue ON light and the red FAULT light cannot be turned on at the same moment because the module cannot correctly regulate output current if a fault is experienced and the output stage of the power supply is disabled.

3.2.1 Internal Protections

Each A3660BS module is equipped with multiple internal protections (hardware and software) to avoid unwanted behaviors or eventual damages to the unit and also to let users run the power supply safely.

All hardware protections are installed on the A3660BS Power Board and are here listed:

- OVC (OVer-Current protection);
- CB (CrowBar protection);
- over-voltage clamping;
- cross-conduction protection.

Several software protections, some of them redundant, are also implemented and here listed:

- DC-Link under-voltage protection;
- OVC (Over-Current protection);
- CB (Crowbar protection);
- MOSFETs over-temperature;
- earth leakage detector.

Protection redundancy – i.e. hardware and software – was especially implemented in order to guarantee a double level of reliability for the specified type of power supplies.

An overview of all available protections, as well as a brief description of their behavior, is presented in the following sections.

3.2.1.2 OVC – OVerCurrent

The OVC check (hardware + software) is performed on each module DC-Link input current (from the corresponding A3667 bulk) and protects from short-circuit conditions that could arise in the output stage section.

This protection is obtained from a Schmitt-triggered signal fed by an opportunely conditioned Hall-sensor that directly disables the output stage bridge driver.

The signal is also fed to the FPGA that disables the output power stage of the A3660BS in case an over-current condition arises.

The acting of the over-current protection generates a FAULT condition on the power supply status register and should be reset before re-enabling the output.

3.2.1.3 CB – CrowBar

The A3660BS module protection against output over-voltage conditions is guaranteed by a crowbar protection circuit that, as in the case of the over-current protection one, has a double level of reliability – i.e. both hardware and software.

This protection is hardware-activated when the output voltage crosses the threshold of:

$$V_{CB\_threshold} = 28.5V$$

This threshold value on the output voltage can be exceeded in situations where a large $\frac{di(t)}{dt}$ value is generated by the energy stored in a large reactive load.

The crowbar circuit also guarantees dissipation of the residual energy stored in the load when turning off the power supply output stage from a high current value on a high inductive load (i.e. 60A on a 20mH magnet).

This protection also activates a galvanically-isolated logic signal that generates a software interrupt on the on-module FPGA: when this signal is activated, the FPGA sets a flag in the status register that needs to be reset before re-enabling the channel output again.

3.2.1.4 Over-Voltage Clamping

The over-voltage behavior obtained from the energy stored by a large inductive load, before the eventual crowbar protection intervention, is heavily limited by a parallel array of active-driven MOSFETs and a high-power resistor. The circuit gets into operation when a defined threshold – i.e. $V_{Over\_Voltage}$ – is exceeded:

$$V_{Over\_Voltage} = 27V$$

3.2.1.5 Cross-Conduction Inhibition

The A3660BS modules are protected from cross-conduction, on both legs of the H-bridge, by a discrete Field-Effect-Transistor network acting directly on the PWM (Pulse Width Modulation) signals.

Cross-conduction conditions are already discarded by the presence of an opportunely tuned dead-time interval between driving signals but this protection gives an extra-level of reliability to this power supply critical stage.

3.2.1.6 DC-Link Under-Voltage

The DC-Link under-voltage protection operates whenever the DC-Link voltage, monitored by a 16-bit ADC on the power supply FPGA, drops below a user-definable threshold.

This situation can be caused either by a generic DC-Link AC/DC failure – e.g. bulk power supply fault or disconnection.

The intervention of this protection disables the output stage driving signals; as in the other cases, a FAULT condition is generated and a "DC-Undervoltage" flag is set in the A3660BS power supply status register. This status register must be reset before turning the output ON again.

Note: this value can be configured writing EEPROM "value" cell 23 (see 'MWF Command' Section for more information).

3.2.1.7 MOSFETs Over-Temperature

The MOSFETs composing the power supply output stage are connected to two different heatsinks (one for each output bridge "leg") that is monitored by high-gain and high-precision temperature sensors.

The FPGA disables the H-Bridge when the maximum temperature (between the two measured ones) rises above a user-defined threshold value, stored in EEPROM cell #20 (factory default values are highly recommended), and sets a "MOSFET over-temperature" flag in the status register, thus generating a FAULT condition that, as in the other cases, needs to be reset before enabling the output again.

Note: this value can be configured writing EEPROM "value" cell 20 (see 'MWF Command' Section for more information).

3.2.1.8 Earth Leakage Current Detector

The earth-leakage current is detected by sensing the current flowing into a shunt resistor that is connected to earth. A common mode current may be present when the load or cabling to the load has a weak isolation to ground.

The voltage (proportional to the current) is measured by a 16-bit ADC so that the threshold that trips the earth current limit fault can be configured by software: EEPROM cell #31 stores this value.

This limit value should be greater than 50mA since the measuring accuracy is about 50mA.

Note: this value can be configured writing EEPROM "value" cell 31 (see 'MWF Command' Section for more information).

3.2.2 External Interlocks

Each A3660BS module has different configurable *dry-contact* input interlocks and some output status signals that are directly available on one the SY3662 rear panel interlock connector.

Each A3660BS has its own interlock connector – i.e. two interlock connectors on each SY3662 crate. The pin index is summarized in **Table 1**:

Pin Number	Function
1	Interlock 1
2	Interlock 1 return
3	Interlock 2
4	Interlock 2 return
5	Interlock 3
6	Interlock 3 return

7	Interlock 4
8	Interlock 4 return
9	Bulk Interlock +
10	Bulk Interlock -
11	*nc*
12	*nc*
13	Solid state Relay
14	*nc*
15	Magnetic Relay NC-TAP
16	Solid state Relay return
17	Magnetic Relay C-TAP
18	Magnetic Relay NO-TAP

Table 1: Rear Interlock Connector Pinout

The two interlock connectors – one for each possible A3660BS module installed in a SY3662 system – are *Weidmuller* 18-pin male connectors. The corresponding pinout is shown in **Figure 5**.

Figure 5: Interlock connector on SY3662 rear panel

Please notice that all interlock pins are galvanically isolated from ground and outputs terminals, nevertheless the absolute maximum voltage, referred to ground, that pins can sustain is 48V.

Note: Do not apply voltage between any input interlock and its corresponding return.

Note: The absolute maximum current that can be sunk by the output status relays (solid state relay pins 13-16 and magnetic relay pins 15-17-18) is 100mA.

Interlock 1 (the displayed interlock name shown on the front display can be changed with the user requirements, see 'MWF command' and Memory mapping sections for further details) is hardware-activated when pin 1 and return pin 2 are shorted.

A magnetic relay provides the Output status of the module: when ON, the Normally Closed contact (NC-TAP) switch opens and vice-versa.

A bulk interlock input (pins 9-10) is also available: the corresponding bulk module can be turned off by shorting these pins.

The extreme configurability of the A3660BS modules allows users to decide what interlocks to enable and what not, the interlock "trip" level – i.e. LOW or HIGH – and the time of intervention (the time that an interlock signal has to be to the trip level before generating a fault condition).

This information can be set and read from the module EEPROM.

An example of mating connector for the interlocks is *Weidmuller B2L 3.50/18/180QV9 SN BK BX model*.

3.2.2.1 Interlocks Enabling/Disabling

Each A3660BS external interlock can be enabled and disabled by writing to the interlock enable mask to the EEPROM cell 48. A value of '1' means that the interlock is enabled while a '0' value that the corresponding interlock is disabled.

The value to be written is the ASCII string, formed by one hexadecimal digit that corresponds to the binary enabling/disabling mask; the four external interlocks are numbered from 1 to 4.

Example: if only interlocks 2 and 4 need to be enabled, the following command needs to be sent to the power supply (after having un-locked the password protection):

MWG:48:A\r

The sent string has to be so interpreted:

A			
1	**0**	**1**	**0**
Interlock 4 *Enabled*	Interlock 3 *Disabled*	Interlock 2 *Enabled*	Interlock 1 *Disabled*

In order to make this command taking effect it is necessary to perform a 'MUP\r' (Module Update Parameters) command – see "MUP command" section for further details.

The MRG:48\r command returns a string containing the ASCII correspondent of the interlock enable mask and contains information about what interlocks are enabled and what are disabled.

3.2.2.2 Interlocks Activation States

Each A3660BS external interlock can be chosen to trip at a HIGH or a LOW logic level. A value of '1' means that the interlock trips when the input signal to the corresponding interlock is shorted and a '0' that the corresponding interlock trips when the input is open.

The value to be written is the ASCII string, formed by one hexadecimal digit, that corresponds to the binary activation state mask; the four external interlocks, as for the interlock enable/disable mask (from 0 to 3), are numbered from 1 to 4.

Example: consider that only interlocks 2 and 4 are enabled – i.e. a "A" string is contained in the EEPROM cell 48 – and interlock 2 needs to trip when the corresponding input signals are shorted (LOW level) while interlock 4 when its input is open (HIGH level); the value to be written to the EEPROM cell 49 is the following:

MWG:49:8\r

The sent string has to be so interpreted:

8			
1	**0**	**0**	**0**
Interlock 4 *HIGH*	Interlock 3 *LOW*	Interlock 2 *LOW*	Interlock 1 *LOW*

In order to make this command taking effect it is necessary to perform a 'MUP\r' (Module Update Parameters) command – see "MUP command" section for further details.

Content of the interlock enable/disable mask – i.e. EEPROM cell 48 – overrides the content of the cell 49 so that the values contained in cell 49 are discarded if the corresponding bit in cell 48 is '0' (and the interlock is disabled).

The MRG:49\r command returns a string containing the ASCII correspondent of the interlock enable mask and contains information about what interlocks are activated at a LOW state and what are activated at a HIGH state.

3.2.2.3 Interlocks Intervention Time

The time of intervention for each enabled interlock on any A3660BS module can be chosen separately with a 1-ms resolution.

EEPROM cells from 50 to 53 contain information on how long an interlock input signal needs to be at its "activation" level before tripping and thus generating a fault condition. Interlock 1 intervention time is stored into EEPROM cell 50 while interlock 4 into EEPROM cell 53.

Example: consider that interlock 4 needs to trip only after 100ms it has reached its activation level. The value to be written into EEPROM memory is the following:

MWG:53:100\r

In order to make this command taking effect it is necessary to perform a 'MUP\r' (Module Update Parameters) command – see "MUP command" section for further details.

Note: values for intervention time have to be included between 0 and 10000 (i.e. 10 seconds).

3.2.2.4 Interlock Configuration Example

Magnets can be water-cooled and there is a usual need for an interlock in case of the water cooling system fault.

Let us consider a water flow switch that, by choice, can be connected to interlock 2 of a SY3662 interlock connector on the rear panel.

Water flow switch signals needs to be connected between pins 5 and 6 of the interlock connector (see **Figure 5**); in order to activate only interlock 2, the following command needs to be sent to the corresponding A3660BS module:

MWG:48:2\r

A correct operation of the magnet cooling keeps the interlock input pins shorted while a fault has to be generated when the input becomes open; the interlock 2 activation level needs to be set to HIGH with the following command:

MWG:49:2\r

The possible presence of air bubbles that may generate same fake faults and some voltage spikes on the interlock input contacts generates the need for a hysteresis on the interlock level: this can be obtained by simply setting the interlock 2 intervention time to a few seconds (4s for example – i.e. 4000ms) in the following way:

MWG:51:4000\r

The previous settings do not become active until a 'MUP\r' (Module Update Parameters) command is sent to the power supply module and a '#AK\r' response has been received.

3.3 EEPROM Memory Mapping

Each A3660BS power supply module has an on-board EEPROM memory that stores all information about calibration parameters, module identification, thresholds, interlock naming and configuration, etc.

Some of these fields can be user-defined and are extremely useful in order to exactly fit the power supply to the specific application.

EEPROM memory size is 256Kbits and was divided into two main different sections, each one consisting of 128Kbits:

- **FIELD** section;
- **VALUE** section.

This section division can be seen in **Figure 6**.

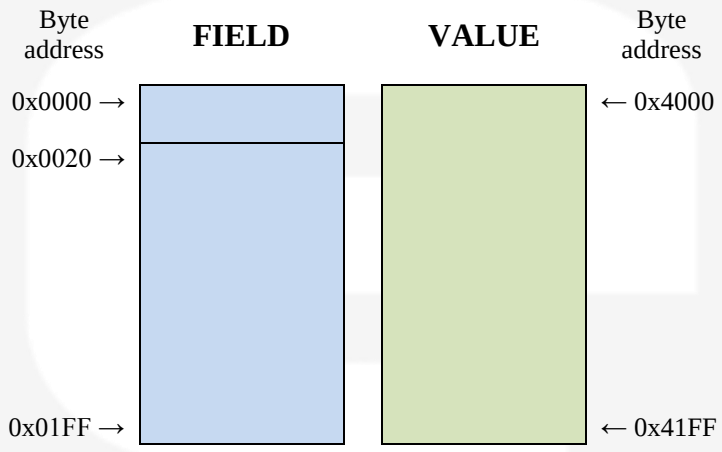


Figure 6: EEPROM memory sections

The EEPROM cell size is 0x20 bytes – i.e. 32 bytes – and, being the content stored in ASCII string format, the total string can contain 31 bytes + '\r' termination character.

Some EEPROM cells are password protected and can be unlocked using the 'PASSWORD' command (see the corresponding section for further details).

The password used to unlock the write-protected EEPROM cells of the modules is "PS-ADMIN".

The EEPROM **"value"** structure and the cell content description are presented in **Table 2**:

Cell #	Cell Caption	Description
0	c_0I_set	Zero-order current calibration coefficient
1	c_1I_set	1st-order current calibration coefficient
2	c_2I_set	2nd-order current calibration coefficient
3	c_3I_set	3rd-order current calibration coefficient
4	I_{max}	Maximum settable current set-point
5	c_0V_read	Zero-order voltage calibration coefficient
6	c_1V_read	1st-order voltage calibration coefficient
7	c_2V_read	2nd-order voltage calibration coefficient
8	c_3V_read	3rd-order voltage calibration coefficient
9	c_0DC_Link	Zero-order DC-link calibration coefficient
10	c_1DC_Link	1st-order DC-link calibration coefficient
11	c_2DC_Link	2nd-order DC-link calibration coefficient
12	c_3DC_Link	3rd-order DC-link calibration coefficient
13	K_P - proportional constant	PID regulator proportional gain
14	K_I - integral constant	PID regulator integrative gain
15	K_D - derivative constant	PID regulator derivative gain
18	Newton-Raphson Iterations	Number of iterations for inverse calibration
19	*reserved*	-
20	Max MOSFET Temperature	Maximum MOSFET heatsinks temperature
21	*reserved*	-
22	Serial Number	Module serial number
23	Undervoltage Protection	Under-voltage protection threshold
24 … 25	*reserved*	-
26	Calibration Date	Date of last calibration
27	Identification	Module identification name
28 … 29	*reserved*	-
30	Slew Rate [A/s]	Module slew rate value
31	Earth Current Limit [A]	Maximum earth leakage current limit
32 … 36	*reserved*	-
37	Regulation fault threshold [A]	Maximum allowable regulation fault current
38	*reserved*	-
39	Ripple fault threshold [A]	Maximum allowable current ripple
40 … 46	*reserved*	-
47	*reserved*	-
48	Interlock Enable/Disable Mask	Enabling/disabling external interlocks
49	Interlock Activation State Mask	Definition of external interlocks active state
50	Interlock 1 Intervention Time (ms)	Intervention time for interlock 1

51	Interlock 2 Intervention Time (ms)	Intervention time for interlock 2
52	Interlock 3 Intervention Time (ms)	Intervention time for interlock 3
53	Interlock 4 Intervention Time (ms)	Intervention time for interlock 4

Table 2: EEPROM "Value" section

Please note that:

- cells marked in **blue** are password-protected;
- cells marked in **green** are not accessible by a standard user (factory-reserved).

All settable parameters need to be updated in order to take immediate effect on the module operation: a 'MUP\r' command needs to be sent to the A3660BS module after all parameters have been set by 'MWG' commands.

The EEPROM **"field"** structure and the cell content description are presented in **Table 3**:

Cell #	Cell Caption	Description
0 … 49	*reserved*	-
50	Interlock 1 identification	Interlock 1 identification name/string
51	Interlock 2 identification	Interlock 2 identification name/string
52	Interlock 3 identification	Interlock 3 identification name/string
53	Interlock 4 identification	Interlock 4 identification name/string

Table 3: EEPROM "Field" section

Please note that cells marked in **blue** are password-protected and need to be unlocked in order to write their content.

Please refer to **Table 2** and **Table 3** to write values and fields to configure correctly the A3660BS module and note that the commands to be used are:

- 'MWG' command to write the respective "value" cell content;
- 'MWF' command to write the respective "field" cell content.

The power supply controller automatically handles EEPROM addresses and "value" and "field" cell sections so that the MWF and MWG commands are almost transparent to the users and there is no need to write complicated cell addresses.

Example: suppose that the proportional term value – K_p – of the internal PID digital regulator has to be changed to 0.15. Referring to **Table 2**, this value is not password protected and it is placed at "value" section cell number 13.

The following command needs to be sent to the A3660BS module:

MWG:13:0.15\r

and should receive an acknowledgment reply from the power supply – i.e. '#AK\r'. Now, the value 0.15 it is stored in the "value" cell number 13 (which is the cell 0x41A0 since the "value" section offset is equal to 0x4000 bytes and each cell length is 0x20 byte). In order to make the module apply the value K_p = 0.15 to its internal regulator, a 'MUP\r' command has to be sent. The changing on the PID regulator parameters should in addition take effect only with the module output OFF.

3.3.1 "Value" Section Cells

Herein, in order to correctly configure and check the power supply operation, a brief description of the "value" section user-definable cells is presented:

- **I_{max}** – *cell 4*: the value contained in this cell defines the maximum current [A] that a user can set to the A3660BS module. This value need to be included between a lower limit 0A and(rated output current) + 0.1A;

- **K_P** – *cell 13*: this value is the proportional gain coefficient of the internal digital PID regulator;

- **K_I** – *cell 14*: this value is the integral gain coefficient of the internal digital PID regulator;

- **K_D** – *cell 15*: this value is the derivative gain coefficient of the internal digital PID regulator;

- **Max MOSFET Temperature** – *cell 20*: this value [°C] defines the temperature threshold above which the power supply generates an over-temperature fault condition. The temperature is directly measured on two separate MOSFETs heatsinks and the maximum value between these two measured temperature is taken into account;

- **Under-Voltage Protection** – *cell 23*: this value [V] defines the DC-Link voltage threshold below what the power supply generates an under-voltage fault condition;

- **Identification** – *cell 27*: this value, a string, defines the A3660BS module identification name (and can be read with the 'MRID\r' command);

- **Slew Rate** – *cell 30*: this value [A/s] determines the slew-rate value of the power supply. The module ramps, using the command 'MRM\r', at a defined set-point with this pre-defined value of slew-rate.

- **Earth Current Limit** – *cell 31*: this value [A] defines the maximum value allowable for the earth leakage current before generating a fault condition and disabling the output stage;

- **Regulation Fault Threshold** – *cell 37*: this value [A] defines the maximum allowable value, calculated as the difference from the actual output current set-point, before generating a fault condition;

- **Ripple Fault Threshold** – *cell 39*: this value [A] defines the maximum allowable value, calculated as the peak-to-peak output current ripple, before generating a fault condition;

- **Interlock Enable/Disable Mask**– *cell 48*: this cell contains and defines the hexadecimal ASCII number that represents the binary mask for the individual setting of interlocks from 1 to 4 (see "Interlocks Enabling/Disabling" for further information);

- **Interlock Activation State Mask**– *cell 49*: this cell contains and defines the hexadecimal ASCII number that represents the binary mask for the individual setting of activation state of interlocks from 1 to 4 (see "Interlocks Activation State" for further information);

- **Interlock 1 to 4 Intervention Time** – *cell 50 to 53*: these cells contain the values of the interlock intervention times in [ms] (see "Interlocks Intervention Time" for further information).

3.4 Status Register

Each A3660BS module has an internal 32-bit status register that contains all useful information about the power supply operation; this register is updated in real-time and it is always accessible by the user via the remote connection.

The internal status register structure is presented in **Table 4** (bit 31 is the MSB and bit 0 the LSB):

Status bit	Cell Caption
31	*not used*
30	DCCT FAULT
29	OPEN LOOP OPERATION
28 … 25	*not used*
24	BULK ON
23 … 20	*not used*
19 … 16	EXTERNAL INTERLOCKS [4…1]
15	RIPPLE FAULT
14	WAVEFORM EXECUTION FLAG
13	TURNING OFF
12	RAMP EXECUTION FLAG

11	REGULATOR FAULT
10	GROUND CURRENT
9	DC UNDERVOLTAGE
8	*not used*
7	MOSFET TEMPERATURE
6	CROWBAR
5	INPUT OVERCURRENT
4	DSP ERROR - TIMEOUT
3	LOCAL
2	*not used*
1	FAULT
0	MODULE ON

Table 4: 32-bit internal status register

The status register value can be directly read by users using the 'MST\r' command. The returned item is a 4-digit hexadecimal ASCII string, corresponding to the equivalent status register. A brief description of all the binary flags is here presented:

- **Module ON** – *bit 0*: this bit is set if the module is enabled and correctly regulating output current;

- **Fault** – *bit 1*: this bit is set if the module has experienced a fault – e.g. generated by an external interlock or an internal protection trip – and the status register has not been reset;

- **Local** – *bit 3*: this bit is set when the A3660BS installed module is working in LOCAL mode, while this bit is cleared – i.e. set to '0' – when working in REMOTE mode;

- **DSP Error – Timeout** – *bit 4*: this bit is set, in conjunction with a fault condition, when the DSP executing the PWM actuation is not correctly operating;

- **Input Overcurrent** – *bit 5*: this bit is set when the input current from the bulk power supply, sensed by a Hall-effect sensor, rises above a hardware-safe threshold. The setting of this bit implies the simultaneous setting of the fault bit;

- **Crowbar** – *bit 6*: this bit is set when the voltage at the output terminals of the module triggers the crowbar protection (see "Internal Protections" section for further details). The setting of this bit implies the simultaneous setting of the fault bit;

- **MOSFET Temperature** – *bit 7*: this bit is set when a MOSFET heatsink over-temperature condition has been experienced. The value that makes this fault trip is the maximum between the two temperatures measured on each leg of the bridge. The setting of this bit implies the simultaneous setting of the fault bit;

- **DC Undervoltage** – *bit 9*: this bit is set when a DC–Link under-voltage condition – i.e. voltage drops below a user-defined threshold – has been recognized. As in other cases, the setting of this bit implies the simultaneous setting of the fault bit;

- **Ground Current** – *bit 10*: this bit is set when a fault generated by an excessive leakage current to ground has been experienced. The setting of this bit implies the simultaneous setting of the fault bit;

- **Regulator Fault** – *bit 11*: this bit is set when a regulation fault is experienced. The setting of this bit implies the simultaneous setting of the fault bit;

- **Ramp Execution Flag** – *bit 12*: this bit is set when the A3660BS module is performing a ramp to a new set-point. After the ramp is finished, and the new set-point is reached, this flag is cleared;

- **Turning Off** – *bit 13*: this bit is set while the A3660BS module is turning off. The A3660BS modules, before disabling the output power stage, ramp down to 0A (zero) with a factory-defined slew-rate of 60A/s.

- **Waveform Execution Flag** – *bit 14*: this bit is set when the A3660BS module is performing a current waveform (see "Waveform Execution" section for further details);

- **Ripple Fault** – *bit 15*: this bit is set when an excessive current ripple on the output current is measured by the internal logic. The setting of this bit implies the simultaneous setting of the fault bit;

- **External Interlocks** – *bit 16 ... 19*: these bits are set when the corresponding enabled external interlocks trip. These bits do not give any information about the activation state of the interlock signals. The setting of anyone of these bits implies the simultaneous setting of the fault bit;

- **Bulk ON** – *bit 24*: this bit is set when the A3667 external bulk power supply unit connected to the A3660BS module is enabled and delivering its DC-Link voltage to the A3660BS module;

- **Open Loop Operation** – *bit 29*: this bit is set when the A3660BS module works in *open-loop mode*. This mode is a new feature on the A3660BS modules and it allows users to set the duty cycle of the module from 0.07 – i.e. 7% – to 0.935 – i.e. 93.5%;

- **DCCT Fault** – *bit 30*: this bit is set when the internal DCCT, used for output current control, has experienced a fault. The setting of this bit implies the simultaneous setting of the fault bit;

4. Local Control

This chapter describes the local control functionalities that are provided on each A3660BS power supply module and some useful information on how to use it.

Each A3660BS module on the SY3662 can be operated independently in LOCAL or REMOTE mode: the switching between the two modes of operations can be set by the on-module encoder and its menus.

After completing this operation, there should an evidence of the power supply being in the desired LOCAL mode: a black "L" character, surrounded by a red rectangle, appears on the upper-left angle of the corresponding A3660BS display installed in the crate (an "R" character is displayed on the same angle when working in REMOTE mode).

The status of the module – e.g. LOCAL / REMOTE – on power-up is stored and recalled from the module internal memory so that each A3660BS powers up in the same state it has been powered down.

4.1 Encoder

Each A3660BS module can be controlled by means of the rotary encoder placed on its front panel.This encoder allows two basic actions:

- **clockwise** (CW) and **counter-clockwise** (CCW) **rotation** in order to change selected menu lines or numbers;
- **pushing** in order to enter sub-menus or to confirm.

The combination of the cited actions allows browsing the power supply menus to read or set desired information and parameters.

4.2 Colour Display

The colour display on each A3660BS front panel allows users to visualize information about the power supply status and to control the unit in order to use it locally (and it also allows switching to REMOTE mode operation). Screens and pages of the display can be navigated from the encoder through user friendly menus and sub-menus.

4.2.1 *Power-up* Page

The A3660BS, upon power-up or power-cycling, should display a yellow warning sign for a few seconds (see **Figure 7**), meaning that the power supply is correctly initializing and loading internal parameters.

Figure 7: *Power-up* display screen

After the initialization is done and internal parameters are correctly loaded, the fans should start rotating at a minimum speed level and the A3660BS display module should go to his "Home Page" screen.

4.2.2 Home Page

The A3660BS home page screen is the first loaded page upon power-up or power-cycling of the module, it is shown in **Figure 8**, and contains information on:

- the module LOCAL/REMOTE state;
- the A3660BS module identification name (content of EEPROM "value" cell 27);
- output current readback value [A], with 1mA resolution;
- output voltage readback value [V], with 1mV resolution;
- status of the power supply.

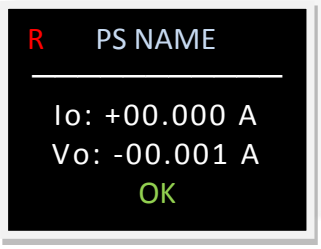


Figure 8: *Home Page* screen

The status indicator of the power supply is continuously blinking as it is updated (every 200 ms) and gives an indication on whether the module is operating correctly or not.

If the module has experienced one or more faults – e.g. interlock intervention, over-temperature, etc. – the home page screen would display a list of all the faults, presenting them in an alternate way, one after the other.

The power supply latches on every fault recognized by the internal logic so that every type of fault is recorded: this means that the first fault happening does not ban the other ones to be recorded so that, giving users more information, permits a better investigation on the fault cause evaluation.

For example, if the module has experienced a regulator fault and a crowbar protection intervention, the home page bottom part of the screen will switch between the red strings "REG FAULT" and "CROWBAR".

If the module it is not turned on and the output is disabled, the home page screen should look like in **Figure 9**:

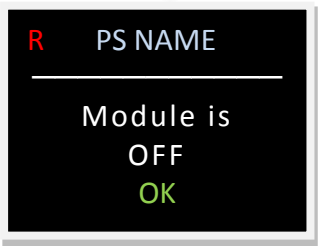


Figure 9: *Home Page* screen with module OFF

4.2.3 Menu Page

The menu page is reachable by clicking the encoder button while being in the home page. Through this page the users have access to all the necessary setting/monitoring functions and sub-menus of the power supply module.

The first screen shown in the Menu Page is shown in **Figure 10**:

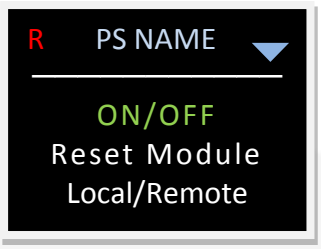


Figure 10: *Menu Page* screen

The accessible sub-menus from this page are herein listed (note that the selected sub-menu is lightened in green color):

- ON/OFF;
- Reset Module;
- Local/Remote
- Set Current;
- Connectivity;
- Global Stats.

A set of two blue arrows (one pointing upward and the other one downward) are shown in the upper right corner of this page in order to indicate the presence of additional sub-menu voices in the selected direction. Users can simply browse through this menu by rotating the encoder (a CW rotation makes the selection going downward in the menu while a CCW one in the opposite direction).

4.2.4 ON/OFF Page

The ON/OFF page can be reached by selecting the "ON/OFF" line in the Menu Page of the A3660BS module.

From this page it is possible to turn on/off the bulk power supply unit connected to the module and the module itself.

In order to perform these operations it is necessary for the module to be in the LOCAL mode (indicated by a black "L" in a red frame in the upper left corner of the display), as shown in **Figure 11**:

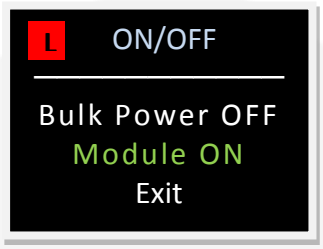


Figure 11: *ON/OFF* screen

The example screenshot shown in **Figure 11** allows turning the module on while the bulk power supply is already on: this can be understood from the fact that the selectable option is "Bulk Power OFF", meaning that the bulk unit is already powered.

The possible choices displayed on this menu are:

- **Bulk Power ON** (if the bulk unit is OFF);
- **Bulk Power OFF** (if the bulk unit is ON);
- **Module ON** (if the module is off and the bulk unit is ON);
- **Module OFF** (if the module is on and the bulk unit is ON).

The choice of the "Exit" line on this menu sends the users back to the Menu Page.

4.2.1 Local/Remote

The Local/Remote choice on the main menu allows users to change the A3660BS status from LOCAL operation to REMOTE and vice versa.

The actual status can be continuously monitored by the "L" or "R" letter on the upper-left corner of the display.

4.2.2 Set Current Page

The "Set Current" page allows users to locally set the current setpoint of the power supply module.

From this page it is also possible to check the actual module output current, indicated as "Io".

In order to perform the current setting operation it is necessary for the module to be in the LOCAL mode (indicated by a black "L" in a red frame in the upper left corner of the display), as shown in **Figure 12**:

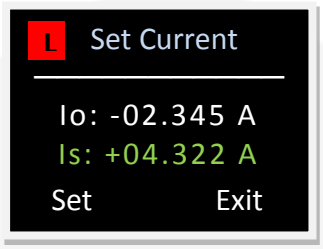


Figure 12: *Set Current* screen

The "Set" text in the bottom left corner of the display needs to be clicked on in order to make the new current setpoint to take effect. The power supply module A3660BS will reach the new setpoint by ramping with the predefined slew rate, which can be checked on the "Connectivity" page of the menu.

By clicking the "Exit" text on the bottom right corner the users can go back to the Menu page.

4.2.3 Connectivity Page

The "Connectivity" page allows users to check the module MAC (*Media Access Control*) address and the IP address as well as also setting the second one.

The A3660BS module IP address can be easily changed from this panel by selecting the new address with the local encoder in the screen shown in **Figure 13**:

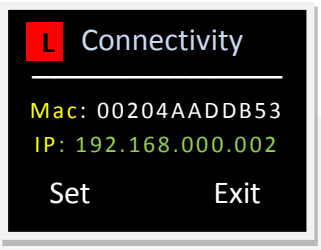


Figure 13: *Set Current* screen

After clicking the "Set" text the power supply should display a window - shown in **Figure 14** - telling the users that the new IP address is configuring. The set operation can be performed only by setting the module to LOCAL mode.

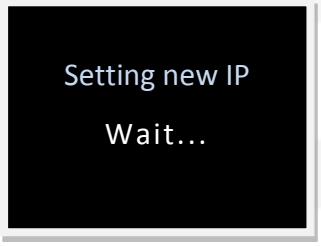


Figure 14: screenshot shown when updating IP address

It is very important to notice that once the "Set" text has been clicked, the user can remotely communicate and get control of the power supply again only by opening a new TCP socket to the IP that has just been set.

4.2.4 Global Stats Page

The "Global Stats" page allows users to check and monitor some of the ancillary features of the power supply module A3660BS as DC-Link voltage, slew rate settings, etc.

An example on how the Global Stats page of the module is presented can be seen in **Figure 15**:

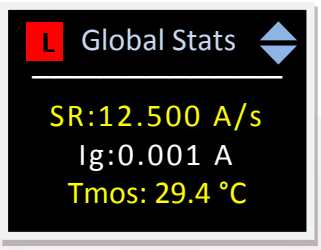


Figure 15: *Global Stats* screen

This page can be browsed by rotating the encoder and can be exited at any moment by clicking on the same encoder pushbutton (this action sends the user back to the Menu Page).

The features that can be displayed on this menu are the following:

- **DC:** the DC-Link voltage measured value [V], obtained from the corresponding A3667;
- **SR:** the defined value for the slew-rate [A/s];
- **Ig:** the measured ground leakage current [A];
- **Tmos:** the maximum measured heatsink temperature [°C], please notice that there are two different heatsinks on the board;
- **FPGAver**: the internal FPGA firmware version;
- **DSPver**: the internal DSP firmware version.

5. Remote Control

Any A3660BS power supply module can be also remotely controlled via a standard Ethernet 10/100 link using a predefined set of commands.

After setting the A3660BS module to REMOTE operation, there should be an evidence of the power supply system being in this mode: a red "R" character should appear on the upper-left angle of the power supply display (an "L" character is displayed on the same angle when working in LOCAL mode).

5.1 Preliminary Information

In order to ensure a correct communication with an A3660BS module, the following rules have to be pointed out:

- commands to the A3660BS power supply module must be sent with a **'\r'** (carriage return, 0x0D hexadecimal number) termination character;
- replies from the A3660BS power supply also have a **'\r'** (carriage return, 0x0D hexadecimal number) termination character.

A complete list of commands (except for reserved commands) is herein presented and an overview for each command syntax and functionality follows.

The extreme configurability of this power supply leads to a very widespread command list, thus typical users may only need a small set of commands in order to run the SY3662 system in a satisfying way.

5.2 List of Commands

The user-available commands, as well as a brief description and their read or write functionality, are summarized in the following table:

Command	Description	Read/Write
BON	Turn the bulk power supply ON	W
BOFF	Turn the bulk power supply OFF	W

FDB	Feedback command	W
HWRESET	Performs and hardware reset of the module	W
MAC	Read MAC and IP addresses of the module	R
MGC	Read ground leakage current value	R
MGLST	Read the main values and status of the module	R
MOFF	Turn the module OFF	W
MON	Turn the module ON	W
MRD	Module Read Duty-cycle	R
MRESET	Reset the module status register	W
MRF	Read selected EEPROM "field" cell	R
MRG	Read selected EEPROM "value" cell	R
MRI	Read output current value	R
MRID	Read module identification	R
MRM	Set output current value (ramp)	W
MRP	Read DC-Link voltage value	R
MRT	Read output stage heatsink temperature	R
MRV	Read output voltage value	R
MRW	Read estimated active output power value	R
MSP	Read last stored output current setpoint	R
MSR	Read or write slew-rate value	R/W
MST	Read module internal status register	R
MUP	Update all EEPROM parameters	W
MWAVE	Set waveform total number of points	W
MWAVEP	Set waveform single point	W
MWAVER	Read stored waveform points	R
MWAVESTART	Start waveform execution	W
MWAVESTOP	Stop waveform execution	W
MWF	Write selected EEPROM "field" cell	W
MWG	Write selected EEPROM "value" cell	W

MWI	Set output current value (no ramp)	W
PASSWORD	Write password to unlock password-protected cells	W
SIP	Set module IP address	W
VER	Read module model and installed firmware versions	R

Table 5: A3660BS module Command List

It is important to notice that some commands are write-only commands (e.g. MRM to set output current) and some others are read-only commands (e.g. MRI to read output current value).

The only command that allows reading and setting is the MSR command, which reads or sets the user-defined slew-rate for the power supply (see 'MSR Command' section for further details).

5.3 Commands Overview

The power supply controller replies every time that a termination character '\r' is received. Replies could have different behaviors:

- an acknowledgment '#AK\r' string is sent back in case of a correct setting command;
- a non-acknowledgment '#NAK\r' string is sent back in case of a wrong/unrecognized command or if the system is in local operation mode and a write command is sent to the controller (write commands are marked with a 'W' in **Table 5**);
- a standard reply, preceded by a '#' and followed by a '\r' character, is sent back as a response to a reading command.

A brief description for each command, in alphabetical order, is herein presented with some example annotations; the correct interpretation for these examples is as follows:

Command sent TO the power supply →

← **Reply FROM the power supply**

5.3.1 "BOFF" Command

The 'BOFF\r' command is intended to turn off the corresponding external bulk power supply unit connected to the A3660BS module by driving low the bulk output stage enabling signal.

As soon as the module receives a 'BOFF\r' command, the bulk power supply turns off.

It is important to notice that the bulk power supply cannot be turned off directly with 'BOFF\r' if the module is in ON state and output current terminals are enabled; it is necessary to turn the A3660BS module OFF first.

Replies from the A3660BS to a 'BOFF\r' command are in the form '#AK\r' or '#NAK\r'; the '#NAK\r' reply is obtained if:

- the module is in LOCAL mode;
- the module is ON, i.e. output current terminals are enabled.

Examples:

BOFF example when the A3660BS module is in LOCAL mode:

BOFF\r →

← #NAK\r

BOFF example while the A3660BS module is enabled – i.e. it is ON:

BOFF\r →

← #NAK\r

BOFF example when the A3660BS module is OFF:

BOFF\r →

← #AK\r

5.3.2 "BON" Command

The 'BON\r' command turns on the external bulk power supply unit connected to the A3660BS module by shorting the bulk output stage enabling contacts.

Replies from the A3660BS to a 'BOFF\r' command are in the form '#AK\r' or '#NAK\r'; the '#NAK\r' reply is obtained if:

- the A3660BS module is in LOCAL mode;
- a fault condition has not been cleared/reset.

Examples:

BON example when the A3660BS module is in LOCAL mode:

BON\r →

← #NAK\r

BON example when the bulk is off and no faults are experienced:

BON\r →

← #AK\r

5.3.3 "FDB" Command

The 'FDB' command is a custom command that was especially implemented in order to minimize traffic on the Ethernet communication socket, having a dedicated request/reply structure.

The feedback command syntax is as follows:

FDB:set_reg:i_set\r

where:

- *set_reg*: is the setting register of the power supply (8-bit wide);
- *i_set*: is the desired output current setpoint value [A].

The power supply reply, after a FDB command, it is in the following format:

#FDB:status_reg:i_set:i_read\r

where

- *status_reg*: is the 32-bit wide *status register* of the PS, formatted in an hexadecimal string; this status string has a fixed-length of 8-byte;
- *i_set*: is the string containing the output current desired setpoint value; string length is 8 bytes (i.e. 8 characters): sign + 2 integers + "." + 4 decimal digits (eg. 1,02A it is returned as +01.0200);
- *i_read*: is the output current readback string; its length is equal to 8 bytes: sign + 2 integers + "." + 4 decimal digits;

The *status_reg* structure is presented in the following table (and in section 3.4):

Status bit	Cell Caption
31	*not used*
30	DCCT FAULT
29	OPEN LOOP OPERATION
28 … 25	*not used*
24	BULK ON
23 … 20	*not used*
19 … 16	EXTERNAL INTERLOCKS [4…1]
15	RIPPLE FAULT
14	WAVEFORM EXECUTION FLAG
13	TURNING OFF
12	RAMP EXECUTION FLAG
11	REGULATOR FAULT

10	GROUND CURRENT
9	DC UNDERVOLTAGE
8	*not used*
7	MOSFET TEMPERATURE
6	CROWBAR
5	INPUT OVERCURRENT
4	DSP ERROR - TIMEOUT
3	LOCAL
2	*not used*
1	FAULT
0	MODULE ON

The *set_reg* structure, in order to set the desired behaviour, must be interpreted as follows:

FDB command register (8bit):	Bit Function:
Bit 7	BYPASS COMMAND
Bit 6	ON/OFF
Bit 5	RESET
Bit 4	RAMP
Bit 3	BULK ON/OFF
Bit 2…0	*don't care*

Example:

Suppose that the PS in ON and it is regulating at a 5.0000A output current.
The user then sends the following command:

FDB:58:-03.2453\r →

← #FDB:00061001:-03.2453:+05.0000\r

After sending the FDB command, the PS turns on (it was already ON) and sets its current to -3.2453A reaching this setpoint with a ramp (defined by the slew rate value stored in the PS non-volatile memory).

The entire reply from the power supply, referred to the format just presented, can be interpreted as follows:

- *Module is ON;*
- *Ramp is executing (Ramp execution flag);*
- *Bulk is ON;*
- *Auxiliary PS earth fault is OK.*
- *actual output current value is 5.0000A;*
- *the new set-point is -3.2453A.*

5.3.4 "HWRESET" Command

The 'HWRESET\r' command performs a complete reset of the hardware and firmware of the on-board FPGA and DSP, thus re-initializing the entire A3660BS module control electronics.

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated when:

- the module is in LOCAL mode;
- the module is ON (it is necessary to turn the module OFF first in order to perform a remote hardware reset).

Examples:

HWRESET example with the module in LOCAL mode:

HWRESET\r →

← #NAK\r

HWRESET example with the module in REMOTE mode:

HWRESET\r →

← #AK\r

It is important to notice that the A3660BS replies with an acknowledgment command "#AK\r" before resetting the internal hardware and firmware.
After reset, the communication to the power supply module can be lost for a few seconds as a consequence of re-initialization.

5.3.5 "MAC" Command

The 'MAC\r' command returns both the MAC address and IP address of the connected A3660BS power supply in the following form:

#MAC:mac_addr:ip_addr\r

where:

- *mac_addr* is the MAC address of the module;
- *ip_addr* is the IP address of the module.

The MAC command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MAC example:

MAC\r →

← #MAC:00204AD4ED5B:192.168.0.10\r

5.3.6 "MGC" Command

The 'MGC\r' command returns the readback value of the actual ground leakage current of the A3660BS power supply in the following form:

#MGC:value\r

where:

- *value* is the earth current value read [A].

The MGC command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MGC example for a 80mA earth leakage current:

5.3.7 "MGLST" Command

The 'MGLST\r' command is a general purpose reading command that returns some useful readback values as well as the power supply global status.

Replies from the A3660BS module are in the following form:

#MGLST:i_out:v_out:status:i_gnd:i_set\r

where:

- *i_out* is the output current value readback [A];
- *v_out* is the output voltage value readback [V];
- *status* is the ASCII representation, composed by eight hexadecimal digits, of the module 32-bit status register;
- *i_gnd* is the ground leakage current read [A];
- *i_set* is the last stored output current setpoint [A].

The MGLST command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MGLST example for an A3660BS module set to -13.0355A:

MGLST\r →

← #MGLST:-13.0356:-5.4321:0003:0.00:-13.0355\r

5.3.8 "MOFF" Command

The 'MOFF\r' command is intended to turn off the A3660BS output drivers, thus disabling the output current terminals.

The 'MOFF\' command automatically sets output current to 0A (zero) with a 60A/s factory default slew-rate before disabling the output drivers; this is done in order to avoid voltage overshoots - that would be anyway smoothed and limited by the crowbar and over-voltage clamping protections - especially for high currents and strongly inductive loads.

Replies from the A3660BS to a 'MOFF\r' command are in the form '#AK\r' or '#NAK\r'; the '#NAK\r' reply is obtained if:

- the module is in LOCAL mode;

Sending a 'MOFF\r' command when the module output is already disabled generates an acknowledgment response – i.e. '#AK\r'.

Examples:

MOFF example when the A3660BS module output is already disabled:

MOFF\r →

← #AK\r

MOFF example when the system is in LOCAL mode:

MOFF\r →

← #NAK\r

MOFF example when the A3660BS module is ON and sourcing/sinking current:

MOFF\r →

← #AK\r

5.3.9 "MON" Command

The 'MON\r' command is intended to turn on the A3660BS output drivers, thus enabling the output current terminals and allowing the power supply to regulate and feed current to the connected load.

After the reception of an 'MON\' command, the power supply automatically sets output current to 0A (zero) when enabling the output.

Replies from the A3660BS to a 'MOFF\r' command are in the form '#AK\r' – when the command is correctly executed - or '#NAK\r'. The '#NAK\r' reply is obtained if:

- the module is in LOCAL mode;
- the corresponding A3667 bulk power supply is not enabled (see 'BON\r' command for further details);
- the A3660BS module is in a FAULT condition (it is necessary to reset the status register after a generic fault condition in order to turn the power supply ON again - see command 'MRESET\r').

Sending a 'MON\r' command when the module output is already enabled generates an non-acknowledgment response – i.e. '#NAK\r'.

Examples:

MON example when the bulk power supply is enabled (ON) and no fault conditions:

MON\r →

← #AK\r

MON example when the system is in LOCAL mode:

MON\r →

← #NAK\r

MON example when the bulk power supply is still disabled (OFF):

MON\r →

← #NAK\r

5.3.10 "MRD" Command

The 'MRD\r' command – mainly intended for debugging purposes – returns the actual value of the duty-cycle applied to the output drivers of the power stage of the A3660BS module. Replies from the A3660BS power supply are in the following format:

#MRD:duty_value\r

where:

- *duty_value* is the internal duty-cycle value presented with a 5-digit precision.

The MRD command, being a reading command, returns a response in any module condition (e.g. local/remote); this reply is "#NAK\r" if the module output is turned off – i.e. disabled.

Values of the allowed duty-cycle values are included between a lower limit of **0.007** and an upper limit of **0.935**.

Examples:

MRD example with the module output disabled:

MRD\r →

← #NAK\r

MRD example with the module output enabled:

MRD\r →

← #MRD:0.73424\r

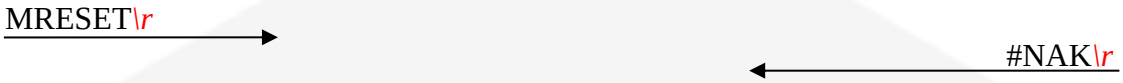
5.3.11 "MRESET" Command

The 'MRESET\r' command has to be used in order to perform a complete reset of the module status register: this is needed, for example, to enable the channel output again after a fault condition has been fixed.

Reply from the A3660BS module is '#AK\r' if the module is set in REMOTE mode and "#NAK\r' if in LOCAL mode.

Examples:

MRESET example when A3660BS in LOCAL mode:



MRESET example when A3660BS in REMOTE mode:

5.3.12 "MRF" Command

The 'MRF\r' command returns the value stored in the "field" parameter of a desired EEPROM cell. The correct form for the reading request is as follows:

MRF:cell_num\r

where:

- *cell_num* is the EEPROM cell number.

The on-board EEPROM memory - used to store module information as calibration parameters, identification, thresholds – has 512 cells, so that *cell_num* is limited between 0 and 511; requests containing cell values exceeding these limits obtain a non-acknowledgment reply '#NAK\r'. The "field" section of the EEPROM is used to store interlocks identification names (cells 50 to 53); for more information on how to write parameters in the "field" area of the memory, please refer to "MWF Command" section.

Replies from the A3660BS power supply are in the following format:

cell_content\r

where:

- *cell_content* is the *cell_num* content in an ASCII representation.

The MRF command, being a reading command, returns a response in any module condition (e.g. local/remote); this reply is a "#NAK\r" also if the memory cell is empty.

Examples:

MRF example with cell_num out of limits:

MRF:539\r →

← #NAK\r

MRF example for a user-defined interlock-related cell (interlock 3):

MRF:52\r →

← THERMAL_SWITCH1\r

5.3.13 "MRG" Command

The 'MRG\r' command returns the value stored in the "value" parameter of a desired EEPROM cell. The correct form for the reading request is as follows:

MRG:cell_num\r

where:

- *cell_num* is the EEPROM cell number.

The on-board EEPROM memory - used to store module information as calibration parameters, identification, thresholds – has 512 cells, so that *cell_num* is limited between 0 and 511; requests containing cell values exceeding these limits obtain a non-acknowledgment reply '#NAK\r'.

A non-acknowledgment response – i.e. '#NAK\r' – is returned also if the field *cell_num* is empty.

The "value" section of the EEPROM is used to store calibration parameters, identification, thresholds, interlock information, etc. and other user-definable factors. For more information on how to write parameters in the "value" area of the memory, please refer to "MWG Command" section.

Replies from the A3660BS power supply are in the following format:

cell_content\r

where:

- *cell_content* is the *cell_num* content in an ASCII representation.

The MRG command, being a reading command, returns a response in any module condition (e.g. local/remote); this reply is "#NAK\r" also if the memory cell is empty.

Examples:

MRG example with cell_num out of limits:

MRG:675\r →

← #NAK\r

MRG example for cell 31 (containing earth current threshold [A]):

MRG:31\r →

← 0.2\r

MRG example for cell 23 (containing DC undervoltage threshold [V]):

MRG:23\r →

← 15.6\r

5.3.14 "MRI" Command

The 'MRI\r' command returns the readback value of the power supply actual output current.

Current readback values have a 20-bit resolution (19-bit + sign) and they are presented with a 5-digit precision.

Replies from the power supply A3660BS to this command are in the following form:

#MRI:value\r

where:

- *value* is the output current value readback [A].

The MRI command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MRI example when the module is OFF:

MRI\r →

← #MRI:+0.00004\r

MRI example when the module is ON and regulating:

MRI\r →

← #MRI:-48.34563\r

5.3.15 "MRID" Command

The 'MRID\r' command returns the A3660BS module identification name as a string.

The reply from the power supply contains the value stored in cell 27 of the module EEPROM and it assumes the following format:

#MRID:module_id\r

where:

- *module_id* is the module identification stored in non-volatile memory, as an ASCII string.

This command is equivalent to the 'MRG:27\r' command, being the cited cell content the user-selected module identification name.

The MRID command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MRID example with the module identification "QuadMag5.2":

MRID\r →

← #MRID:QuadMag5.2\r

5.3.16 "MRM" Command

The 'MRM' command is used to set the value of the desired output current set-point:

MRM:value\r

where:

- *value* is the output current desired set-point [A].

The difference between the 'MWI\r' command and the 'MRM\r' command is that the first one generates a direct change in output current characterized by the PID regulator parameters (slew-rate value is discarded and the command is ideally suited for small output current changes and feedback purposes) while the second one makes the power supply go from the previous to the actual current value performing a ramp, defined by a slew-rate (in A/s) stored in the EEPROM cell 30.

The A3660BS module responds with acknowledgment command '#AK\r' if the value is correctly set and with a '#NAK\r' if:

- the set *value* is out-of-range (the maximum settable current value is user-defined and stored in EEPROM cell 4);
- the module is OFF (it is necessary to turn the module ON first);
- the module performing a ramp (it is necessary to wait for the power supply to end the previous ramp) or a waveform;
- the module is in LOCAL mode.

Examples:

MRM example with the A3660BS module in OFF state:

MRM:-51.872\r →

← #NAK\r

MRM example with the A3660BS module ON and not ramping nor performing a waveform:

MRM:36.1234\r →

← #AK\r

5.3.17 "MRP" Command

The 'MRP\r' command returns the value of the A3667 bulk power supply actual voltage, i.e. DC Link, measured at the A3660BS module input terminals.

Readback values have a unipolar 16-bit resolution (i.e. no sign).

Replies from the power supply A3660BS controller to this command are in the following format:

#MRP:value\r

where:

- *value* is the measured DC Link voltage [V].

Even if the internal ADC dedicated to this purpose has a 16-bit resolution, this value is presented to the user only with a 100 mV resolution.

The MRP command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MRP example when the bulk power supply is disabled:

MRP\r →

← #MRP:0.0\r

MRP example when the A3667 bulk power supply is enabled (after a 'BON\r' command):

MRP\r →

← #MRP:24.8\r

5.3.18 "MRT" Command

The 'MRT\r' command returns the maximum value of the temperatures directly measured on each one of the output stage "leg" heatsinks.

Even if the internal ADCs have a 16-bit resolution, this value is presented to the user with a 0.1 °C (= 0.1 K) resolution.

The module internal logic compares the temperature values measured on each "leg" of the full-bridge and then selects the maximum value between these two, thus giving an indication on the "hottest" part of the A3660BS module.

Replies from the power supply A3660BS controller to this command are in the following form:

#MRT:value\r

where:

- *value* is the temperature value [°C = Celsius] measured on the output stage heatsink.

The MRT command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MRT example:

MRT\r →

← #MRT:34.8\r

5.3.19 "MRV" Command

The 'MRV\r' command returns the readback value of the power supply actual output voltage, measured at the A3660BS module output terminals.

As for the output current, voltage readback values have a 20-bit resolution (19-bit + sign) and they are presented with a 5-digit precision.

Replies from the power supply A3660BS controller to this command are in the following form:

#MRV:value\r

where:

- *value* is the output voltage readback [V], measured at the module output terminals.

The MRV command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MRV example when the module is OFF:

MRV\r →

← #MRV:+0.00012\r

MRV example when the module is ON and regulating output current:

MRV\r →

← #MRV:+11.54563\r

5.3.20 "MRW" Command

The 'MRW\r' command returns the actual value of the estimated active power supplied to the connected load.

This estimation, being computed as the product of the output voltage and the output current readback values, has the same 20-bit resolution and it is presented with a 5-digit precision.

Replies from the power supply A3660BS controller to this command are in the following form:

#MRW:value\r

where:

- *value* is the output active power readback [W], estimated as the product of output voltage and output current readbacks.

The MRW command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MRW example when the module is OFF:

MRW\r →

← #MRW:-0.00432\r

MRW example when the module is ON and regulating output current:

MRW\r →

← #MRW:1022.72345\r

5.3.21 "MSP" Command

The 'MSP\r' command returns the value of the power supply last stored set-point current value.

Replies from the power supply A3660BS controller to this command are in the following form:

#MSP:value\r

where:

- *value* is the last stored output current set-point value [A].

The MSP command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MSP example when the module is OFF:

MSP\r →

← #MSP:+1.23456\r

5.3.22 "MSR" Command

The 'MSR' command it is the only read/write command for the A3660BS and allows reading and setting of the value of the slew rate, in A/s, of the power supply.

The reading command is structured as follows:

MSR:?\r

and the related reply format is:

#MSR:value\r

where:

- *value* is actual slew-rate value for the power supply [A/s], that is the content of the EEPROM cell 30, with a 5-digit precision.

The value of the slew-rate can also be set, between lower limit of 0 A/s and upper limit of 1000 A/s, using the MSR command and adopting the following syntax:

MSR:set_value\r

where:

- *set_value* is desired slew-rate value [A/s].

The MSR setting command generates, upon reception, an acknowledgment – i.e. '#AK\r' - reply if the value is correctly set and with a '#NAK\r' if:

- the set *value* is incorrect (e.g. out of limits);
- the module is still performing a ramp (it is necessary to wait for the power supply to end the previous ramp) or is performing a waveform,
- the module is in LOCAL mode.

Examples:

MSR reading example:

MSR:?\r →

← #MSR:15.00000\r

MSR setting example with a value out of limits:

MSR:13005\r →

← #NAK\r

MSR setting example to a correct value:

MSR:5.5\r →

← #AK\r

5.3.23 "MST" Command

The 'MST\r' command returns the value of the power supply internal status register (32 bit).

Replies from the A3660BS power supply module to this command are in the following format:

#MST:value\r

where:

- *value* is the ASCII representation of the internal status register value, composed by 8 hexadecimal digits, and corresponding to the 32-bit wide status register.

The MST command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

MST example with the module ON, ramping and in LOCAL mode:

MST\r →

← #MST:01000009\r

5.3.24 "MUP" Command

The 'MUP\r' (Module UPdate) command performs an update of the power supply A3660BSactual parameters with the parameters read from the module EEPROM.

As an example, the MWF command updates only the content of the selected EEPROM field but not the corresponding A3660BS parameters. In order to make the module update its parameters it is necessary to perform the 'MUP\r' command: this was done not to apply wrong or undesired transmitted values on-the-fly without wanting it.

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated when:

- the module is in LOCAL mode;
- the module is ON (it is necessary to shut-down the channel with MOFF command first).

Examples:

MUP example with the module OFF and system in REMOTE mode:

MUP\r →

← #AK\r

MUP example with the module ON and/or in LOCAL mode:

MUP\r →

← #AK\r

5.3.26 "SIP" Command

The 'SIP' command allows setting remotely the A3660BS power supply module IP address.

In order to set a new IP address to a module it is necessary to know the actual one (this is possible by checking the "Connectivity" menu on the local color display of the module or by using the DeviceInstaller® software that can be found at www.lantronix.com).

The correct format syntax for this command is:

SIP:ip_addr\r

where:

- *ip_addr* is desired new IP address for the connected module is formed by four decimal numbers (each ranging from 0 to 255) separated by dots;

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated when:

- the A3660BS module is in LOCAL mode;
- the A3660BS module is ON (it is necessary to disable the channel with the MOFF command first for safety purposes);
- the sent IP address is incorrect.

Examples:

SIP example with a correct IP address:

SIP:192.168.0.55\r →

← #AK\r

After this command, the Ethernet module on the A3660BS re-initializes and connection to the host is lost.

SIP example with the module in LOCAL mode:

SIP:192.168.0.55\r →

← #NAK\r

SIP example with an incorrect IP address:

SIP:192.168.0.324\r →

← #NAK\r

It is very important to notice that once the SIP command has been executed, the user can communicate and get control of the power supply again only by opening a new TCP socket to the IP that has just been set.

5.3.27 "VER" Command

The 'VER\r' command returns information about the A3660BS module model and the currently installed firmware versions.

The response to a 'VER\r' command is in the following format:

#VER:A3660BS:FPGA_ver:DSP_ver\r

where:

- *FPGA_ver* is the FPGA firmware version currently installed on the module;
- *DSP_ver* is the DSP firmware version currently installed on the module;

It is important to notice that A3660BS modules include two firmware versions – one for the FPGA and one for the control DSP – keep them up to date by checking for updates/upgrades on the website (www.CAEN ELS.com).

The VER command, being a reading command, returns a response in any module condition (e.g. local/remote).

Examples:

VER example:

VER\r →

← #VER:A3660BS:1.0.1:2.1\r

5.3.28 "MWAVE" Command

The 'MWAVE' has to be used to load current waveform points that can be subsequently executed; the A3660BS module has the capability of executing a pre-loaded waveform with a 1-ms update period (i.e. 1 kHz update rate).

The correct format for this command is as follows:

MWAVE:sample_num:sample_value\r

where:

- *sample_num* is sample number of the waveform, ranging from 0 – i.e. the first sample – to the last sample number, defined by (*tot_points* – 1) (see MWAVEP command for details);
- *sample_value* is the sample current set-point value [A].

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated when:

- the A3660BS module is in LOCAL mode;
- the A3660BS module is executing a waveform;
- the *sample_num* value is greater than the one defined for the number of points of the pre-loaded waveform (by a MWAVEP command);
- the *sample_value* of the current is greater than the maximum value defined for the settable current (defined in EEPROM "value" cell #4).

Examples:

MWAVE correct example:

MWAVE:15:-46.32255\r →

← #AK\r

MWAVE example with a sample_num greater than the waveform length (MWAVEP):

MWAVE:15:-46.32255\r →

← #NAK\r

5.3.29 "MWAVEP" Command

The 'MWAVEP' command defines the maximum number of points – i.e. length – of a pre-loaded point-by-point current waveform.

The correct format for this command is as follows:

MWAVEP:tot_points\r

where:

- *tot_points* is the total number of points of the waveform (ranging from 0 – i.e. no-points – to 60000 – i.e. 60-second waveform).

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated when:

- the total number of points *tot_points* is out of range;
- the A3660BS module is in LOCAL mode;
- the A3660BS module is executing a waveform.

Examples:

MWAVEP correct example:

MWAVEP:2000\r →

← #AK\r

MWAVEP example with the module performing a waveform:

MWAVEP:2000\r →

← #NAK\r

5.3.30 "MWAVER" Command

The 'MWAVER' command returns the value of the selected current waveform set-point sample.

The value returned by this command is the same one that was previously stored with a MWAVE command use.

The correct format for this command is as follows:

MWAVER:sample_num\r

where:

- *sample_num* is the index of the selected sample which value has to be returned.

The MWAVER command, being a reading command, returns a response in any module condition (e.g. local/remote) except if *sample_num* is over the defined range.

Replies from the A3660BS module are in the following format:

#MWAVER:value\r

where:

- *value* is the current value stored in the selected sample.

Examples:

MWAVER example for a correct request:

MWAVER:264\r →

← #MWAVER:1.45323\r

MWAVER example for a sample_num value out of range:

MWAVER:180000\r →

← #NAK\r

5.3.31 "MWAVESTART" Command

The 'MWAVESTART' command is used to make the A3660BS module execute the pre-defined loaded waveform.

The correct form format for this command is as follows:

MWAVESTART:cycles\r

where:

- *cycles* is the total number of periods that the waveform has to be executed (its period length can be defined using the MWAVEP command).

The module can execute the current waveform for a fixed number of periods ranging from 1 to 1440 (equal to a 24-hour total execution time for a 60000 points waveform).

The infinite execution of the waveform is also possible and it is obtained by passing to power supply a -1value, so that:

'MWAVESTART:-1\r'

repeats the waveform for an INFINITE number of cycles

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated, as it is for the MRM command, when:

- the module is in LOCAL mode;
- the module is still performing a ramp (it is necessary to wait for the power supply to end the previous ramp) or it is performing a waveform;
- the module is OFF (it is necessary to turn the module ON first);
- the number of cycles value is out-of-range – i.e. greater than 1440.

Examples:

MWAVESTART example with an excessive number of cycles:

MWAVESTART:1458\r →

← #NAK\r

MWAVESTART example that starts an infinite waveform:

MWAVESTART:-1\r →

← #AK\r

MWAVESTART example that repeats the waveform for 20 cycles:

MWAVESTART:20\r →

← #AK\r

5.3.32 "MWAVESTOP" Command

The 'MWAVESTOP\r' stops the execution of a running waveform (that was previously started with a MWAVESTART command).

This command immediately stops the execution of the stored current waveform that is running and ramps down current to 0A (zero) with the factory default slew-rate of 60A/s.

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated, as it is for the MRM command, when:

- the A3660BS module is in LOCAL mode;
- the module is not executing a waveform;

Examples:

MWAVESTOP example when module is not performing a waveform or is in LOCAL:

MWAVESTOP\r →

← #NAK\r

MWAVESTOP example with a waveform running:

MWAVESTOP\r →

← #AK\r

5.3.33 "MWF" Command

The 'MWF' command lets users write a desired "field" item in a defined EEPROM cell.

The correct form format for this command is as follows:

MWF:cell_num:cell_content\r

where:

- *cell_num* is the EEPROM cell number;
- *cell_content* is the ASCII content to be written to the EEPROM cell *cell_num*.

The on-board EEPROM memory - used to store module information as calibration parameters, identification, thresholds and divided in two sections, "field" and "value" – has 512 cells, so that *cell_num* is limited between 0 and 511; writing operations containing cell values exceeding these limits obtain a non-acknowledgment reply '#NAK\r'.

This "field" section of the EEPROM is used to store descriptive items as interlocks identification names (cells 50 through 53).

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated when:

- the A3660BS module is in LOCAL mode;
- the cell number *cell_num* is out-of-range (negative or greater than 511);
- *cell_num* or *cell_content* are empty strings;
- the selected cell is password protected and password protection is not unlocked (see 'PASSWORD\r' command for further details).

Examples:

MWF example with the module in LOCAL mode:

MWF:52:INTERLOCK_A\r →

← #NAK\r

MWF correct example (after password is unlocked):

MWF:52:INTERLOCK_A\r →

← #AK\r

5.3.34 "MWG" Command

The 'MWG' command lets users write a desired "value" item in a defined EEPROM cell.

The correct form format for this command is as follows:

MWG:cell_num:cell_content\r

where:

- *cell_num* is the EEPROM cell number;
- *cell_content* is the ASCII content to be written to the EEPROM cell *cell_num*.

The on-board EEPROM memory - used to store module information as calibration parameters, identification, thresholds and divided in two sections, "field" and "value" – has 512 cells, so that *cell_num* is limited between 0 and 511; writing operations containing cell values exceeding these limits obtain a non-acknowledgment reply '#NAK\r'.

This "value" section of the EEPROM is used to store descriptive calibration parameters, identification, thresholds, etc. and some cells are password protected (see the "EEPROM Memory Mapping" section to check what cells are protected and what are not).

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated when:

- the A3660BS module is in LOCAL mode;
- the cell number *cell_num* is out-of-range (negative or greater than 511);
- *cell_num* or *cell_content* are empty strings;
- the selected cell is password protected and password protection is not unlocked (see 'PASSWORD\r' command for further details).

Examples:

MWG example with the A3660BS module in LOCAL mode:

MWG:52:INTERLOCK_A\r →

← #NAK\r

MWG example of a correct "write" operation (cell 13 is not password-protected):

MWG:13:0.055\r →

← #AK\r

MWG example (cell 1 is password-protected and password not unlocked):

MWG:1:15.234\r →

← #NAK\r

5.3.36 "MWI" Command

The 'MWI' command can be used to set the output current value and it is used when fast set-point changes are needed.

The use of this command is alternative to the MRM (Module RaMping): the power supply reaches the desired output current value just using the PID regulator parameters, without ramping with the pre-defined slew rate to the new set-point.

This command is usually needed when running feedback-related applications and for small changes in the output current.

The correct form format for this command is as follows:

MWI:value\r

where:

- *value* is the desired output current value [A].

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated, as it is for the MRM command, when:

- the set *value* is out-of-range (the maximum settable current value is user-defined and stored in EEPROM cell 4);
- the module is OFF (it is necessary to turn the module ON first);
- the module performing a ramp (it is necessary to wait for the power supply to end the previous ramp) or a waveform;
- the module is in LOCAL mode.

Examples:

MWI example with the module OFF:

MWI:-48.55679\r →

← #NAK\r

MWI example with the module ON and already regulating:

MWI:13.50\r →

← #AK\r

It is very important to notice that, even if the module is ON and regulating the output current correctly, an MWI command can generate a "Crowbar" intervention and a consequent fault if the current change step is too large, especially for large inductive loads; this is due to the large di(t)/dt that generates voltage peaks.

5.3.37 "PASSWORD" Command

The 'PASSWORD' command can be used to unlock the EEPROM cells that are password protected in order not to let inexperienced users to change some power supply parameters that might compromise the correct operation of the module.

See "EEPROM Memory Mapping" section for further details on password-protected cells.

The correct form format for this command is as follows:

PASSWORD:password\r

where:

- *password* is the module password to unlock protected EEPROM cells.

Replies from the power supply are in the form '#AK\r', or '#NAK\r'; this non-acknowledgment reply is generated, as it is for the MRM command, when:

- the written *password* is incorrect.

Examples:

PASSWORD example with a wrong password:

PASSWORD:elephant\r →

← #NAK\r

PASSWORD example with the right password:

PASSWORD:administrator\r →

← #AK\r

The password to unlock password-protected cells is:

PS-ADMIN

5.4 IP Address Configuration

The easiest way to configure the A3660BS module IP address is to set it by the *Connectivity* menu on the unit LOCAL control – i.e. encoder and display (see section 4.2.3 for further details).

In other cases, when accessibility to the power supply by the user is not possible, there is the need to configure the IP address REMOTELY.

The situations can be mainly two:

- the actual power supply IP address is known by the user. In these case the new IP address configuration can be performed with one of the two following methods:
    - by using the SIP command (see section 5.3.26 for further details);
    - via a basic Telnet connection.
- the actual power supply IP address is NOT known by the user. In this case the new IP address configuration can be performed by using the DeviceInstaller® software.

An overview of the procedures to be followed using the just cited methods is herein presented.

5.4.1 IP Address configuration - SIP command

If the power supply IP address is know by the user, it is possible to configure the new IP address by using the SIP command.

This operation must be performed when:

- the A3660BS module is in REMOTE mode;
- the A3660BS module is OFF (it is necessary to disable the channel with the MOFF command first for safety purposes);
- the sent IP address is correct.

If one of the three just cited conditions is not satisfied, the power supply will not operate any change in its IP address and will reply with a non-acknowledgment command.

The format used to set the IP address must be as follows:

SIP:ip_addr\r

If the power supply actual IP address is known and there's an active connection to the module, the configuration can be performed, for example, as follows.

SIP:192.168.0.55\r →

← #AK\r

Obviously, after the new IP is set, the Ethernet module will reset and the connection to the host PC (or device) will be lost. A new connection must be established to the new IP address - e.g. 192.168.0.55.

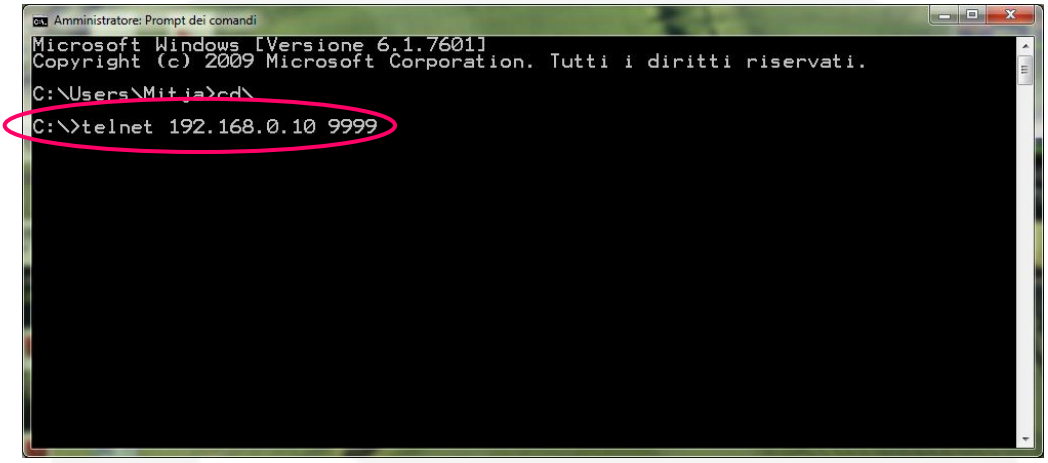
5.4.2 IP Address configuration - TELNET connection

If the power supply IP address is know by the user, it is also possible to configure the new IP address by using a simple TELNET connection.

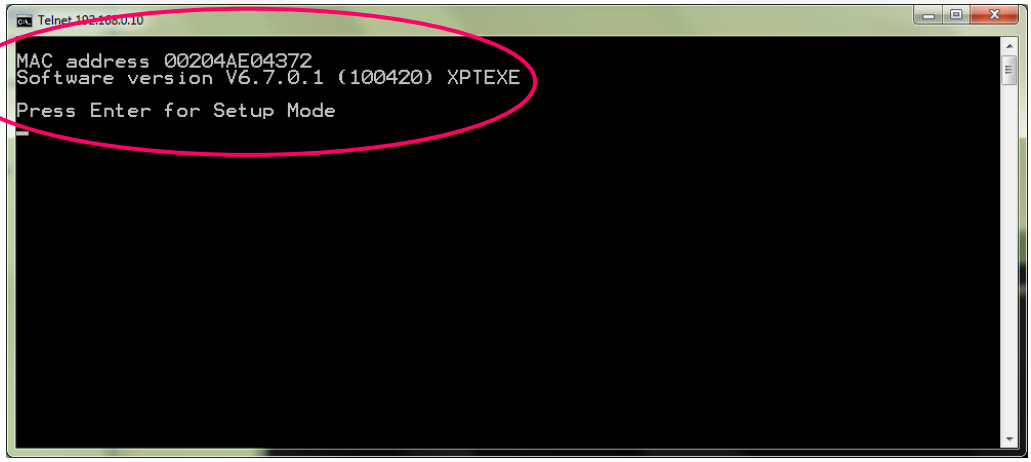
The TELNET connection must be established to **port 9999** of the Ethernet device of the power supply module.

Please carefully follow the instructions in order to correctly set/change the IP address of the A3660BS module:

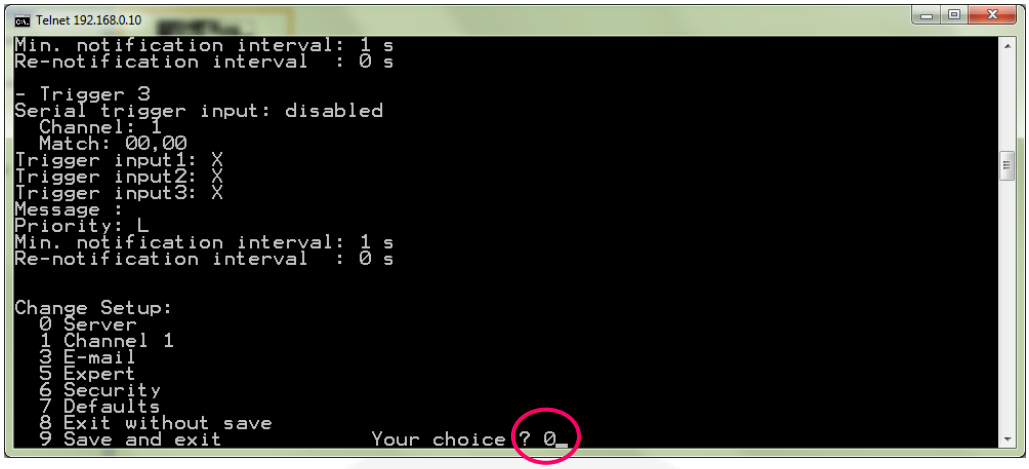
- establish a TELNET connection to port 9999 of the module IP address - e.g. 192.168.0.10;


Amministratore: Prompt dei comandi
Microsoft Windows [Versione 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. Tutti i diritti riservati.
C:\Users\Mitja>cd\
C:\>telnet 192.168.0.10 9999

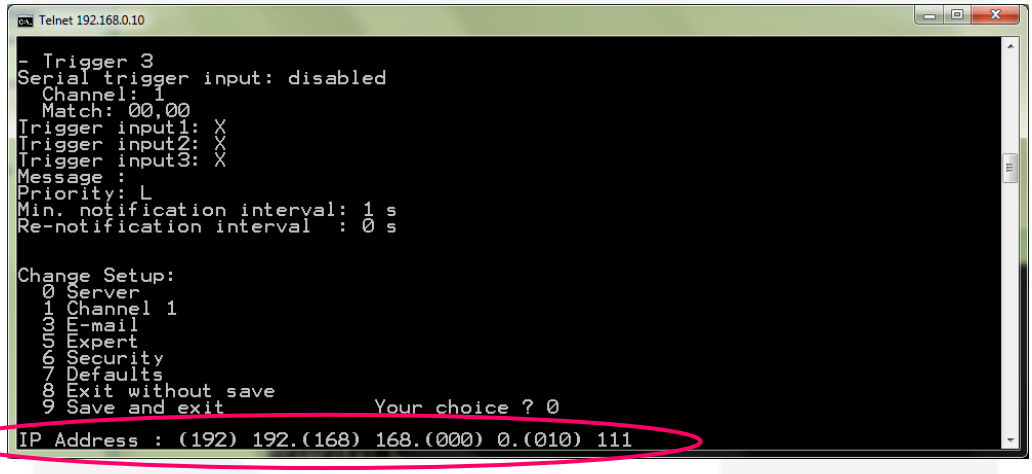
- now press Enter on the prompt to enter configuration menu;



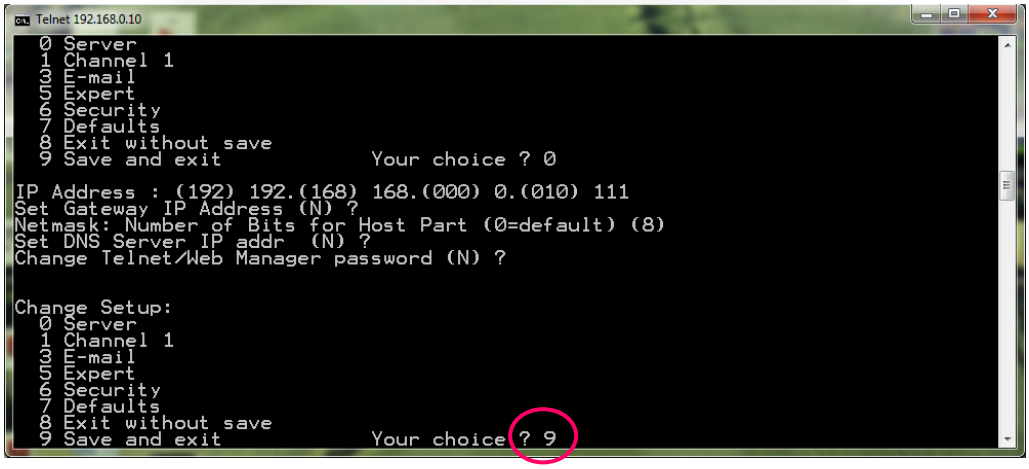
- on the device Telnet-based menu first select the "Server" option by inserting "0" and by pressing Enter on the prompt.



- when asked for the "IP Address" please enter the desired new IP address for the power supply. Please note that the IP address must be entered as 4 three-digit number - e.g. 192.168.0.111;



- Press the Enter key until reaching the "Your choice" screen again. Now insert "9" - i.e. Save and exit - and press Enter again.



The device should now reboot in order for the changes to take effect.

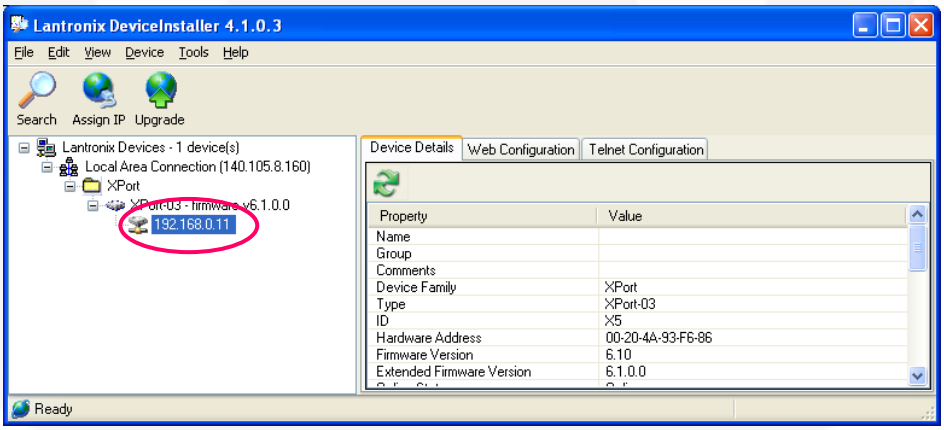
5.4.3 IP Address configuration - DeviceInstaller®

If the power supply IP address is not know by the user and local access to the module is not possible, the best way to find out and to configure the module IP address is to use the DeviceInstaller® software.

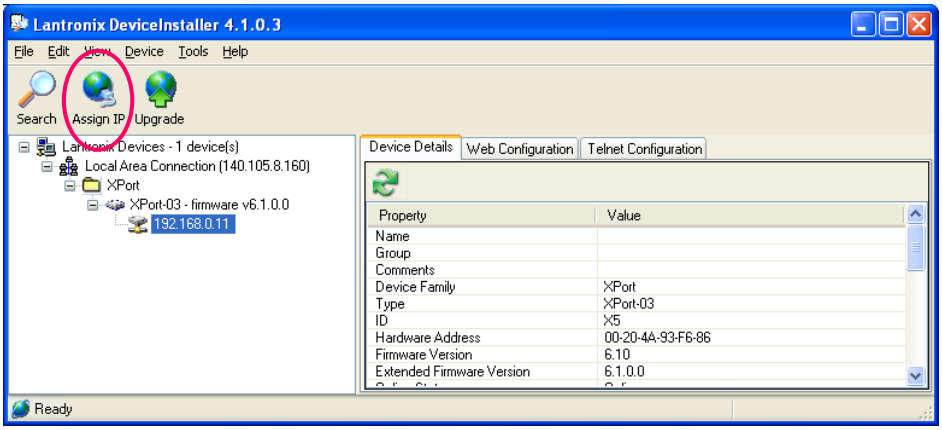
The DeviceInstaller® software can be downloaded for free from the Lantronix website www.lantronix.com.The A3660BS modules can be connected to a global LAN or point-to-point (recommended in order to obtain minimum delays, maximum speed performance and to avoid possible communication problems). Please note that for a point-to-point direct connection a twisted Ethernet cable must be used.

The next few steps must be followed in order to assign a new IP address to the module:

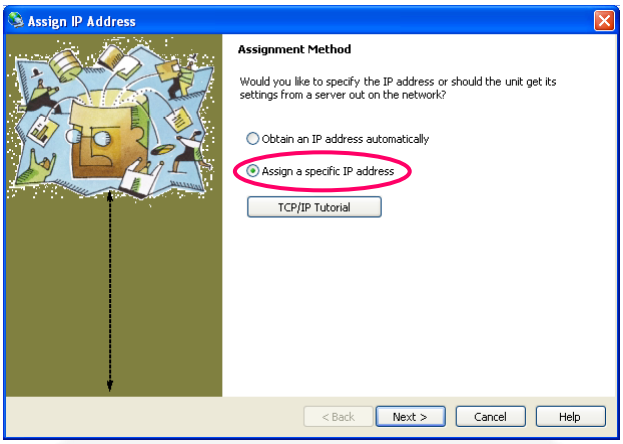
- Connect to the desired A3660BS module with a twisted Ethernet cable;
- Verify that the "Link LED" on the RJ45 connector is turned on (amber for a 10Mbps connection or green for a 100Mbps connection);
- Launch the "DeviceInstaller" program;
- Select the XPort device where you want to change the IP address;



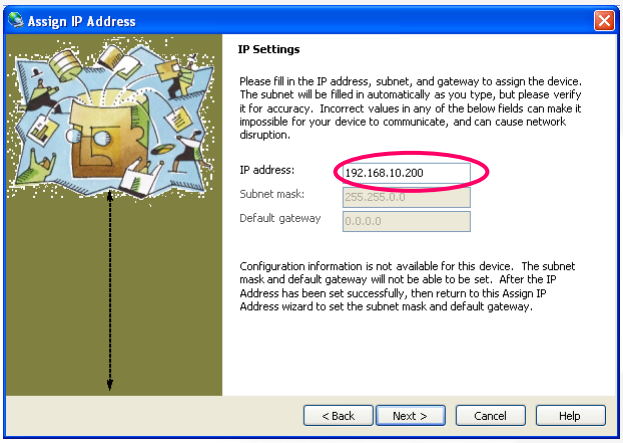
- Click on the "Assign IP" icon;



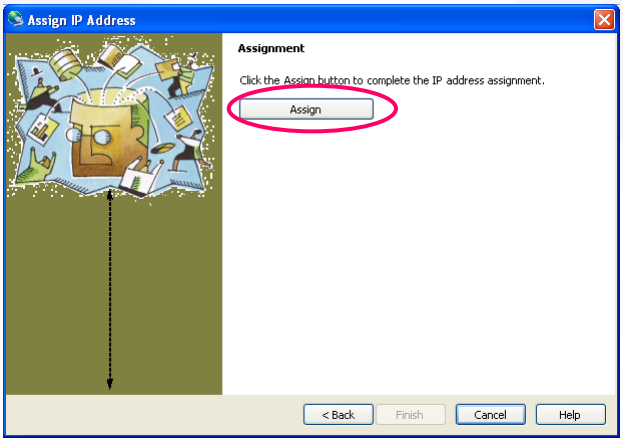
- Select "Assign a specific IP address" and then click "Next";


Assign IP Address
Assignment Method
Would you like to specify the IP address or should the unit get its settings from a server out on the network?
Obtain an IP address automatically
Assign a specific IP address
TCP/IP Tutorial
< Back
Next >
Cancel
Help

- Complete the "IP address" field and click on "Next";


Assign IP Address
IP Settings
Please fill in the IP address, subnet, and gateway to assign the device. The subnet will be filled in automatically as you type, but please verify it for accuracy. Incorrect values in any of the below fields can make it impossible for your device to communicate, and can cause network disruption.
IP address:
192.168.10.200
Subnet mask:
255.255.0.0
Default gateway
0.0.0.0
Configuration information is not available for this device. The subnet mask and default gateway will not be able to be set. After the IP Address has been set successfully, then return to this Assign IP Address wizard to set the subnet mask and default gateway.
< Back
Next >
Cancel
Help

- Click on the "Assign" button;



- Wait for the assignment procedure to end, and then click "Finish".

The new module IP address should now be assigned and the success of the operation can be verified on the "DeviceInstaller" main window (if the window does not refresh, click on "Search").

6. Technical Specifications

Technical Specifications for the SY3662 system crate components, the A3667 bulk and auxiliary power supply and the A3660BS module are here presented.

	A3667 Bulk and Aux Power Supply
Input voltage	100 – 240 V(AC) 50 / 60Hz
Recommended Input Fuse Rating	110V(AC): 8AT 230V(AC): 15AT
Power Factor	> 0.9
Output voltage	+24V +15V -15V
Output current	60A @ 24V 0.6A @ +15V 0.6A @ -15V
Line regulation	+24V: 0.4%
Load regulation	+24V: 0.8%
Efficiency (typ.)	+24V: 85 %
Protections	Input Over-Voltage Output Over-Voltage Output Over-Current (short circuit protection) Over-Temperature
Other Features	+24V: "trimmable" from 22.5V to 25.5V
Dimensions	19 TE - 3U high Euro-mechanics

	A3660BS
Output current range	± 60 A
Output voltage range	± 20 V
Maximum output power	1200 W
Current setting resolution	458 µA
Output current readback	20 bit
Output voltage readback	20 bit
Output current ripple*	100 ppm / FS
Output current stability	20 ppm / FS
DC/DC efficiency	92%
Switching Frequency	100 kHz
Accuracy	0.05%
External Interlocks/States	4 Inputs: user-configurable "dry" contacts 3 Outputs: relay-type (2 magnetic + 1 solid-state)
Internal Interlocks	DC Link Under-Voltage Output Stage Over-Temperature Over-Current Over-Voltage Earth Fault Current Regulation Fault Excessive Current Ripple
Hardware protections	Input Fuses Over-Voltage
Auxiliary ADC Read-Backs (16 bit resolution)	DC Link Voltage Earth Leakage Current MOSFETs Temperature
Cooling	On-Module Self-Regulated Fans
Connection	Ethernet 10/100 Mbits
Extra-Features	Hot-Swap Point-by-Point Current Waveform Loading User-definable interlock thresholds, active levels and timings DSP and FPGA Firmware Remote Updates Open-Loop Operation
Dimensions	23 TE - 3U high Euro-mechanics

Input Voltage	+15V / -15V / +24V
Local Control / Monitor	Graphic Color Display and Encoder 6 LEDs

* measured on a resistive load

Annex A - Output Connectors

Feed-through terminal block - RWO 8/S - 3056145

Please be informed that the data shown in this PDF Document is generated from our Online Catalog. Please find the complete data in the user's documentation. Our General Terms of Use for Downloads are valid (http://download.phoenixcontact.com)

Feed-through terminal block, Connection method: Bolt connection, Load current : 125 A, Cross section: 2.5 mm² - 35 mm², AWG 14 - 2, Connection direction of the conductor to plug-in direction: 0 °, Width: 20.3 mm, Color: gray

Why buy this product

- Easy grouping with engagement pin versions
- Both terminal halves can be easily assembled by simply snapping them together
- Spring-loaded spacers protect the bolt connection against loosening
- Molded versions ensure maximum tightness of seal
- Automatic compensation of the panel thickness via the snap principle integrated in the insulation housing

Key commercial data

Packing unit	0
Minimum order quantity	1
Catalog page	Page 684 (CC-2011)
GTIN	4 046356 427159
Custom tariff number	85369010
Country of origin	CHINA

Technical data

General

Number of levels	1
Number of connections	2
Color	gray
Insulating material	PA
Inflammability class according to UL 94	V0

Dimensions

Width	20.3 mm

Technical data

Maximum load current	125 A
Rated surge voltage	6 kV

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Technical data

Technical data

Pollution degree	3
Surge voltage category	III
Insulating material group	I
Connection in acc. with standard	IEC 60947-7-1
Nominal current IN	125 A
Nominal voltage UN	1000 V
Open side panel	nein

Connection data

Conductor cross section solid min.	2.5 mm²
Conductor cross section solid max.	35 mm²
Conductor cross section stranded min.	2.5 mm²
Conductor cross section stranded max.	35 mm²
Conductor cross section AWG/kcmil min.	14
Conductor cross section AWG/kcmil max	2
Connection method	Bolt connection
Screw thread	M8
Tightening torque, min	4.5 Nm
Tightening torque max	5 Nm

Classifications

eclass

eCl@ss 4.0	27141111
eCl@ss 4.1	27141111
eCl@ss 5.0	27141134
eCl@ss 5.1	27141134
eCl@ss 6.0	27141134
eCl@ss 7.0	27141134

etim

ETIM 3.0	EC001283
ETIM 4.0	EC001283

unspsc

UNSPSC 6.01	30211811
UNSPSC 7.0901	39121410
UNSPSC 11	39121410
UNSPSC 12.01	39121410
UNSPSC 13.2	39121410

Approvals

Feed-through terminal block - RWO 8/S - 3056145

Approvals

Approvals

UL Recognized / GOST

Ex Approvals

Approvals submitted

Approval details

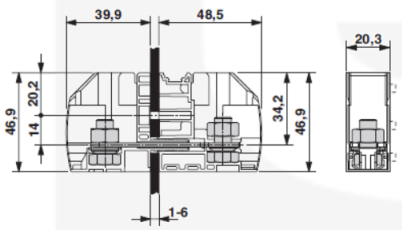
UL Recognized

	B	C
Nominal current IN	115 A	115 A
Nominal voltage UN	600 V	600 V

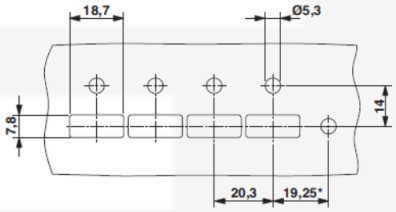
GOST

Drawings

Dimensioned drawing



Dimensioned drawing



Connections to the load must be carried out considering that the DC output connector pinout is presented in **Figure 16**:

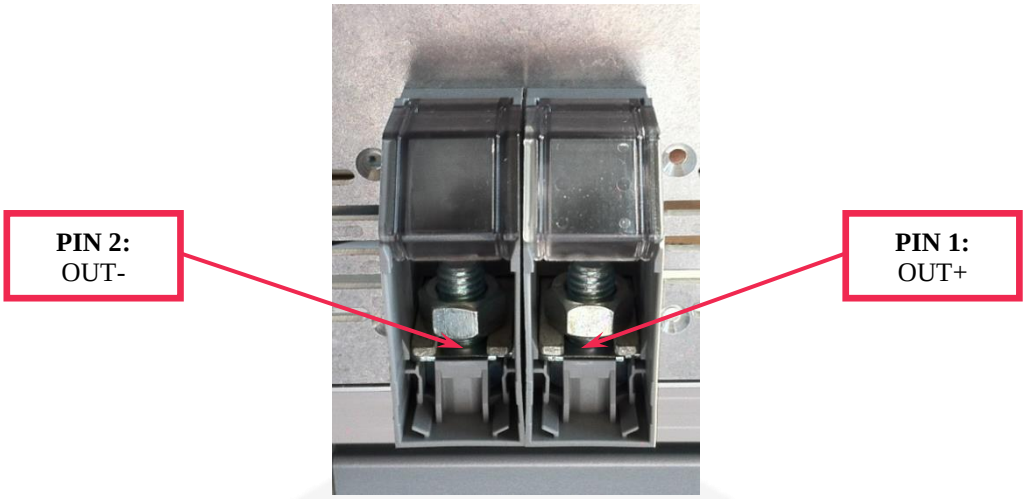


Figure 16: output connector pinout

The corresponding pinout is:

- **pin 1**: positive output terminal;
- **pin 2**: negative output terminal;